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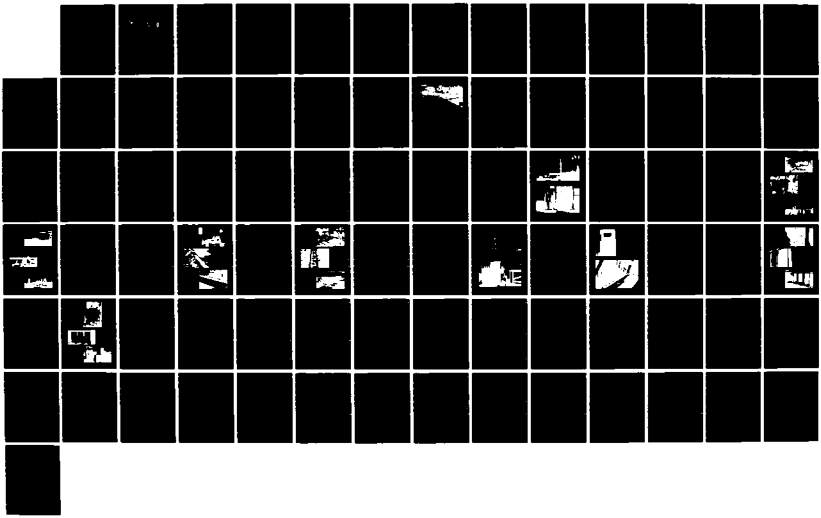

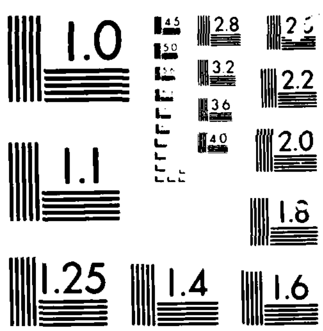

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PEARL HARBOR Z-LOOP UPGRADE
PROJECT COMPLETION REPORT

FPO-1-83(34)
OCTOBER 1983

PREPARED BY

ROBERT TAGGART INCORPORATED
FAIRFAX, VIRGINIA

86 4 22 082

FOR

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
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MCM single conductor cable, was installed during September-October 1982. A series of guide piles outlining the periphery of the intended route allowed the project team to lay the cables without excessive spread. The tight bundle produced assures that a uniform magnetic field is generated. In conjunction with this upgrade, the existing magnetometer array was serviced and surveyed. Non-functioning instruments were replaced and all instrument tube elevations and locations documented.

The final phase of the project involved fabrication and installation of a new junction box assembly, connecting the Z-loop cables to the power plant. The junction boxes were installed in January 1983. At that time, electrical code violations were discovered which necessitated redesign of the terminal strips. These new strips, as well as replacement door assemblies, were installed in May-June 1983.

The deperming facility was restored to full operating status, in support of fleet operations, in June 1983.

PEARL HARBOR Z-LOOP UPGRADE
PROJECT COMPLETION REPORT

FPO-1-83(34)
OCTOBER 1983

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FAIRFAX, VIRGINIA

FOR

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CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20374

ABSTRACT

The existing Z-loop of the deperming facility, Magnetic Silencing Facility, U. S. Naval Station, Pearl Harbor, Hawaii has been upgraded.

The existing Z-loop, consisting of 30 loops of 500 MCM cable, was reported CASREP in July 1982. The new Z-loop, consisting of 104 loops of 500 MCM single conductor cable, was installed during September-October 1982. A series of guide piles outlining the periphery of the intended route allowed the project team to lay the cables without excessive spread. The tight bundle produced assures that a uniform magnetic field is generated. In conjunction with this upgrade, the existing magnetometer array was serviced and surveyed. Non-functioning instruments were replaced and all instrument tube elevations and locations documented.

The final phase of the project involved fabrication and installation of a new junction box assembly, connecting the Z-loop cables to the power plant. The junction boxes were installed in January 1983. At that time, electrical code violations were discovered which necessitated redesign of the terminal strips. These new strips, as well as replacement door assemblies, were installed in May-June 1983.

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1.0 PROJECT DESCRIPTION

BACKGROUND

The existing deperming Z-loop at the Magnetic Silencing Facility (MSF), Naval Station Pearl Harbor (NAVSTA PEARL) was installed in 1963; it consisted of 30 loops of 500 MCM cable. With a number of cables faulted as a result of age, the magnetic field intensity that could be generated approached a minimally acceptable level. The Z-loop was scheduled for upgrade commencing April 1982. This date was slipped back to November 1982 for two reasons. First, the deperming facility at the Naval Station San Diego was undergoing repairs during the summer of 1982; therefore, no West Coast deperming facility would be available if the Pearl Harbor MSF was also down. Second, the Chesapeake Division, Naval Facilities Engineering Command, Ocean Engineering and Construction Project Office (CHESNAVFACENGCOM, FPO-1) had other priority construction commitments that delayed project planning and design. These commitments postponed the anticipated project start date to February 1983.

PLANNING CONSIDERATIONS

Continued Z-loop deterioration ultimately resulted in a Casualty Report (CASREP) situation report in July 1982. Due to the serious impact of this condition on fleet support, the Naval Sea Systems Command (NAVSEA) assigned a high priority to this installation and requested that CHESNAVFACENGCOM expedite installation of the NAVSTA PEARL Z-loop.

The then current schedule was to award a construction contract in the February 1983 time frame; this, however, was not considered sufficiently expeditious.

Alternative approaches considered were: a) use of Naval Construction Forces (NCF) to accomplish the full installation; b) accelerated design and construction contracting; and c) a combination of a) and b).

Planning meetings among representatives of CHESNAVFACENGCOM, Commander, Construction Battalion, Pacific (COMCBPAC), and Commander-in-Chief, Pacific Fleet (CINCPACFLT) were held in August 1982. As a result, it was recommended that Underwater Construction Team Two (UCT-TWO) be utilized to support this effort, specifically for in-water/underwater work, with the

shoreside portion to be performed by the Public Works Center (PWC), contractor or by station forces.

Based on the fleet requirement for urgency of installation and the excellent training opportunity in underwater construction, the support of UCT-TWO was approved by the Chief of Naval Operations (CNO) in a message to CINCPACFLT of 202242Z Aug 82. UCT-TWO was tasked with the in-water/underwater work for the cable-laying phase of the project. The area would be prepared and all the Z-loop cables laid by the Team with shoreside support from Station forces. Because UCT-TWO's home port cycle would then be underway, the remainder of the wet work would be done by others.

It was agreed that the topside junction box installation would be performed by PWC personnel and the underwater assembly would be performed by a dive team from the Mobile Diving and Salvage Unit One (MDSU-ONE). MDSU-ONE would route the cables into the junction boxes from below.

2.0 PROJECT PLANNING

PROJECT REQUIREMENTS

The project requirements established by NAVSEA for the Z-loop upgrade were:

a) Remove the old Z-loop and magnetometer cables to clear the path for the new cable installation.

b) Install eight guide piles for the loop.

c) Lay the new Z-loop consisting of 125 loops of 1.5-inch diameter 500 MCM deperming cable and secure for connection to the system. The new loop would follow the path of the existing loop.

d) Survey and reset the magnetometer array.

e) Install a new junction box assembly.

The cable removal phase was essentially a quality assurance procedure to minimize interference with the new system and insure that a uniform magnetic field would result, unencumbered by tangled and/or wayward nonfunctioning components.

In order to generate sufficient magnetic field strength, 125 loops were ideally required, based on cable capacity and existing power generating equipment. The existing magnetometer garden could not be degraded as a result of this installation. The survey would also serve as an aid to anticipated future instrument replacement--a record of existing position and condition would be established. To complete the upgrade, the newly laid deperming cable would be connected to the facility power house through junction boxes designed to accommodate the expanded Z-loop.

Due to the high priority of expediting the installation of the new Z-loop to restore the MSF Pearl Harbor deperming capability, one project requirement was modified during on-site planning meetings. It was decided to abandon the old Z-loop in place (rather than remove completely) for several reasons.

An underwater inspection revealed the existing loop to be inextricable from innumerable instrumentation cables, both functioning and nonfunctioning. Removal of the old loop would mean grounding the entire sensor array, by

unavoidable cable breaks caused by the removal. Additionally, time constraints precluded the refurbishment of all the instruments and considerable dive time would be avoided with an abandon-in-place scenario, both from the removal and reinstallation viewpoints.

SCHEDULE REQUIREMENTS

The deperming facility maintained a minimal magnetic treatment capability in July 1982. The awarding of a construction contract to upgrade the facility had been anticipated to result in a February 1983 start of operations. As outlined previously, the facility lost even minimal required magnetic field strength generating ability in mid-July 1982 and a CASREP was issued. As a critical fleet support facility, the upgrade was rescheduled for commencement as soon as necessary personnel and materials could be assembled. Accordingly, the Z-loop upgrade was scheduled for September-October 1982, with junction box installation scheduled for December 1982. Figure 2-1 shows the anticipated project milestones and events. The actual calendar of events is also shown for comparison.

The complete installation summary is detailed in Section 7 of this report.

ORGANIZATIONAL RESPONSIBILITIES

The following is a list of the major contributors to project completion. The Major Function column is not a comprehensive listing, but rather a description of the most identifiable contribution by each command or unit.

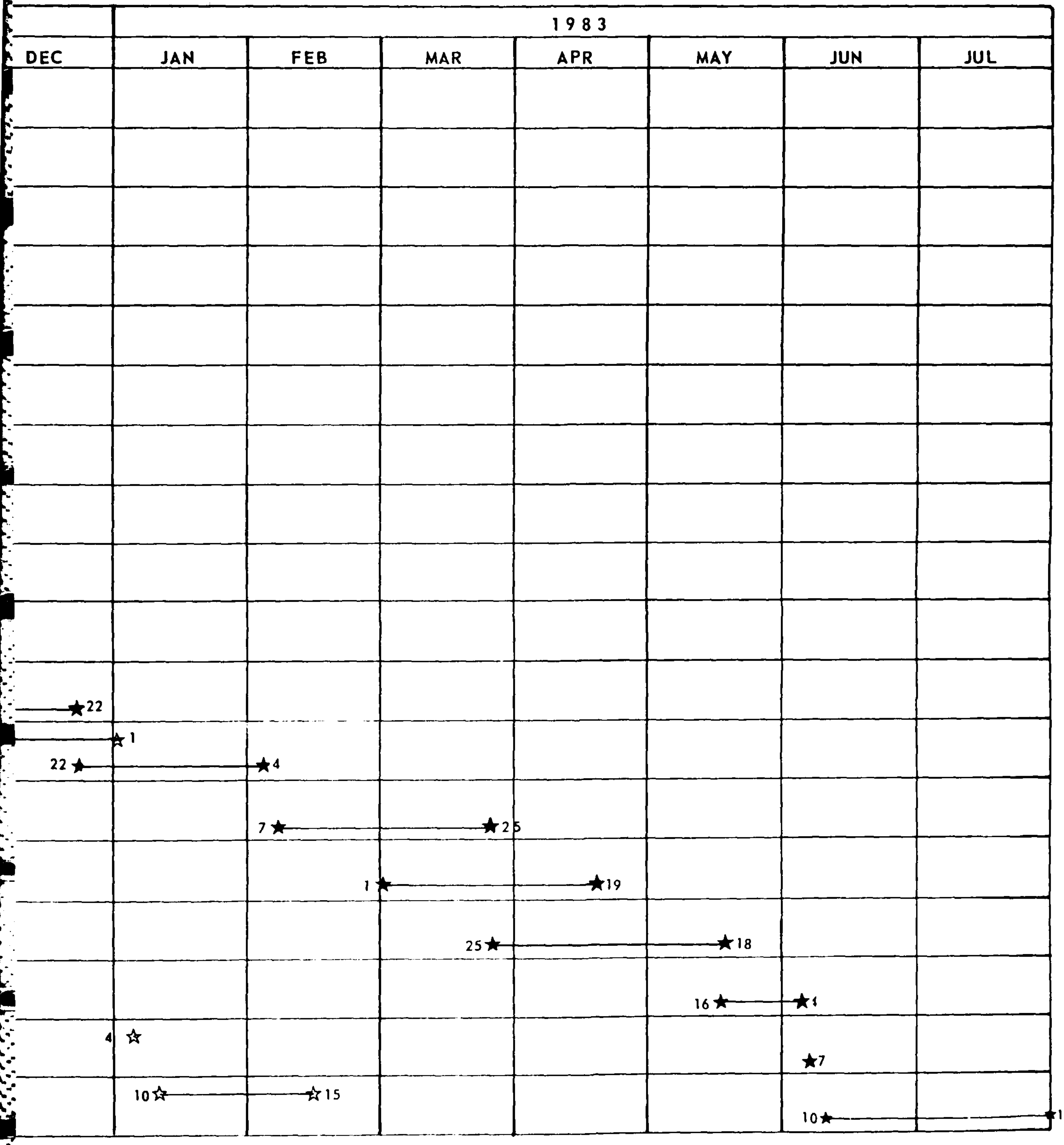
ORGANIZATION	MAJOR FUNCTION
NAVAL SEA SYSTEMS COMMAND	PROVIDED TASKING AND FUNDING TO CHESNAVFACENGCOM FOR DESIGN AND INSTALLATION OF THE Z-LOOP REPLACEMENT.
CHESAPEAKE DIVISION, NAVAL FACILITIES ENGINEERING COMMAND, OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE (CHESNAVFACENGCOM, FPO-1)	PROVIDED PROJECT MANAGEMENT, ENGINEERING, AND ON-SITE TECHNICAL SUPPORT. PROCURED MATERIALS. PROVIDED PROJECT SUPERVISION, FINANCIAL MANAGEMENT, AND PROJECT COMPLETION REPORT.
UNDERWATER CONSTRUCTION TEAM TWO (UCT-TWO)	PROVIDED PETTY OFFICER IN CHARGE OF CONSTRUCTION (POIC) AND PERSONNEL WHO PERFORMED IN-WATER/UNDERWATER CONSTRUCTION TASKS DURING CABLE-LAYING PHASE. PROVIDED DIVING GEAR AND SMALL CRAFT. FURNISHED INPUT TO OPERATION TASKS.
MOBILE DIVING AND SALVAGE UNIT ONE (MDSU-ONE)	PROVIDED POIC AND PERSONNEL WHO PERFORMED IN-WATER/UNDERWATER CONSTRUCTION TASKS DURING JUNCTION BOX INSTALLATION PHASE. PROVIDED DIVING GEAR AND CRAFT FOR DIVE PLATFORM.

ORGANIZATION	MAJOR FUNCTION
PUBLIC WORKS CENTER, PEARL HARBOR (PWC PEARL)	PROVIDED ENGINEERING SUPPORT FOR PILE-DRIVING PHASE AND JUNCTION BOX COUNTERWEIGHT. INSTALLED JUNCTION BOXES. TERMINATED AND CONNECTED Z-LOOP AND POWER FEED CABLES. PROVIDED CONSTRUCTION EQUIPMENT.
NAVAL STATION, PEARL HARBOR (NAVSTA PEARL)	PROVIDED LCM-6 WORK BOAT FOR CABLE LAYING AND YC BARGE FOR TRANSPORTING/STAGING CABLE REELS AND JUNCTION BOXES. PROVIDED ADDITIONAL LABOR SUPPORT.
MAGNETIC SILENCING FACILITY (MSF) (NAVSTA PEARL)	PROVIDED LOCAL PROCUREMENT SUPPORT, BERTHING FOR UCT-TWO PERSONNEL, LABOR SUPPORT FOR SHORESIDE OPERATIONS. FINAL USER.

	1982 (AUG – SEP – OCT – NOV – DEC) Planned	1982 (AUG – SEP – OCT – NOV – DEC) Actual
UCT-TWO SET UP AT PEARL HARBOR	23 (AUG) – 31 (AUG)	23 (AUG) – 31 (AUG)
UCT-TWO MAIN PARTY MOBILIZATION	30 (AUG)	30 (AUG)
STAGING AND LOADING REELS	1 (SEP)	1 (SEP)
UNDERWATER SITE SURVEY	2 (SEP)	2 (SEP)
DEPERM OPERATION	4 – 9 (SEP)	4 – 9 (SEP)
PILE DRIVING	9 – 14 (SEP)	9 – 16 (SEP)
LAY CABLES	15 (SEP) – 13 (OCT)	17 (SEP) – 19 (OCT)
INSTRUMENT SURVEY	2 – 4 (SEP)	20 – 27 (OCT)
UCT-TWO DEMOBILIZATION	15 (OCT)	29 (OCT)
JUNCTION BOX DESIGN	4 (SEP) – 10 (NOV)	4 (SEP) – 15 (OCT)
JUNCTION BOX FABRICATION & SHIPMENT	29 (SEP) – 1 (DEC)	20 (SEP) – 22 (DEC)
SITE PREPARATION AND JUNCTION BOX INSTALLATION	25 (NOV) –	22 (DEC) –
TERMINAL STRIP REDESIGN AND APPROVAL		
DOOR ASSEMBLY REDESIGN/APPROVAL		
COMPONENT FABRICATION & SHIPMENT		
!UNCTION BOX REFIT		
-LOOP TESTING & ACCEPTANCE	4	
EPORT WRITING ROJECT FINALIZATION		

☆——☆ PLANNED

★——★ ACTUAL



PEARL HARBOR Z-LOOP UPGRADE
SCHEDULE OF MAJOR EVENTS

FIGURE 2-1

3.0 SYSTEM DESIGN

The critical need for expeditious completion of the project, to return the deperming facility to operational status, precluded the preparation of a formal Project Execution Plan (PEP). Typically, the PEP would outline the overall project, including materials, preparations, intended installation methods, and contingencies in the event of any potential equipment or operational failure. The preparation of the PEP forces all those concerned to consider in advance all sources of potential difficulty and formulate ideas for their resolution, thus minimizing costly downtime. Further, it provides a reference from which the completion report can extract salient points.

Although a PEP was not published, intended installation methods were formulated, contingencies considered, and alternatives proposed.

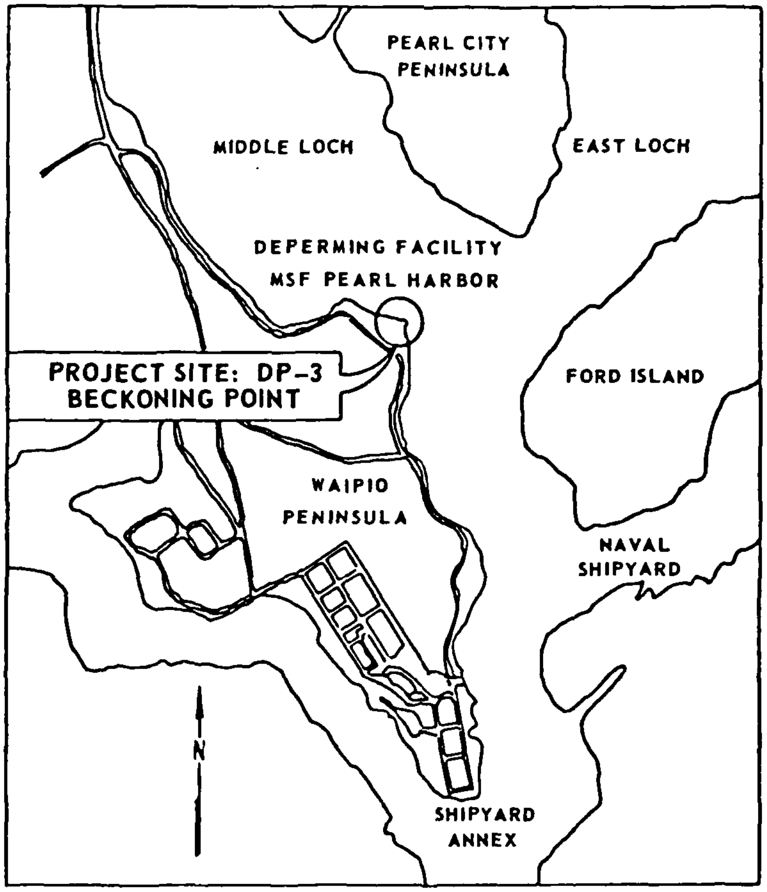
Z-LOOP CABLE-LAYING REQUIREMENTS

The deperming facility at Pearl Harbor Naval Station is open on three sides, the western boundary being defined by three quays backed by a wooden support pier. Figure 3-1 shows the site location.

This open configuration necessitated driving a series of guide piles, around which the cable loops could be uniformly laid, Figures 3-2 and 3-3. The timber guide piles form the outline for the cable loop, a rectangular laying path 510 feet long by 80 feet wide, matching the dimensions of the existing loop. After laying all the cables, the guide piles would be cut off near the cable bundle, allowing unobstructed vessel entry. The cables would terminate in a new junction box system, to be repositioned from the north quay, as existing, to the south quay.

The open nature of the site necessitated use of a powered work platform to lay cable while traversing the loop. The need for excellent maneuverability and adequate deck space to provide for a minimum of four cable reels led to selection of an LCM-6 work boat as the cable-laying vessel.

Staging for cable reels was provided by a YC barge moored just south of the Z-loop site. When onboard reels were handled, the LCM could transit to the YC barge, and, with a cherry picker on board the barge, off-load empty reels and reload full reels. Load capacity of the barge was 70 reels.



LOCATION PLAN FOR PEARL HARBOR
Z-LOOP REPAIR PROJECT

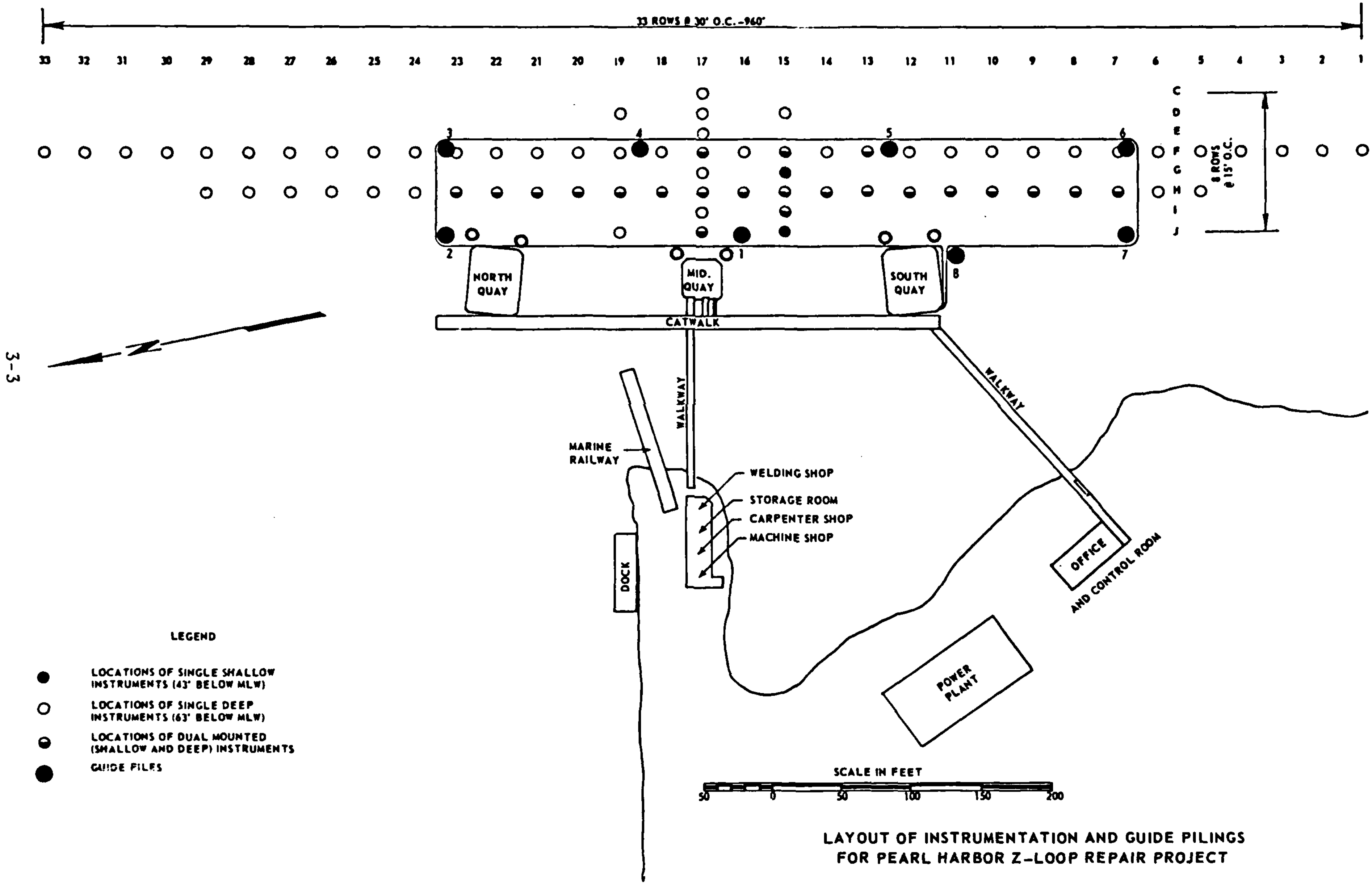
FIGURE 3-1

Additional reels were to be warehoused on Ford Island and transferred to the barge after the initial load was installed.

JUNCTION BOX DESIGN

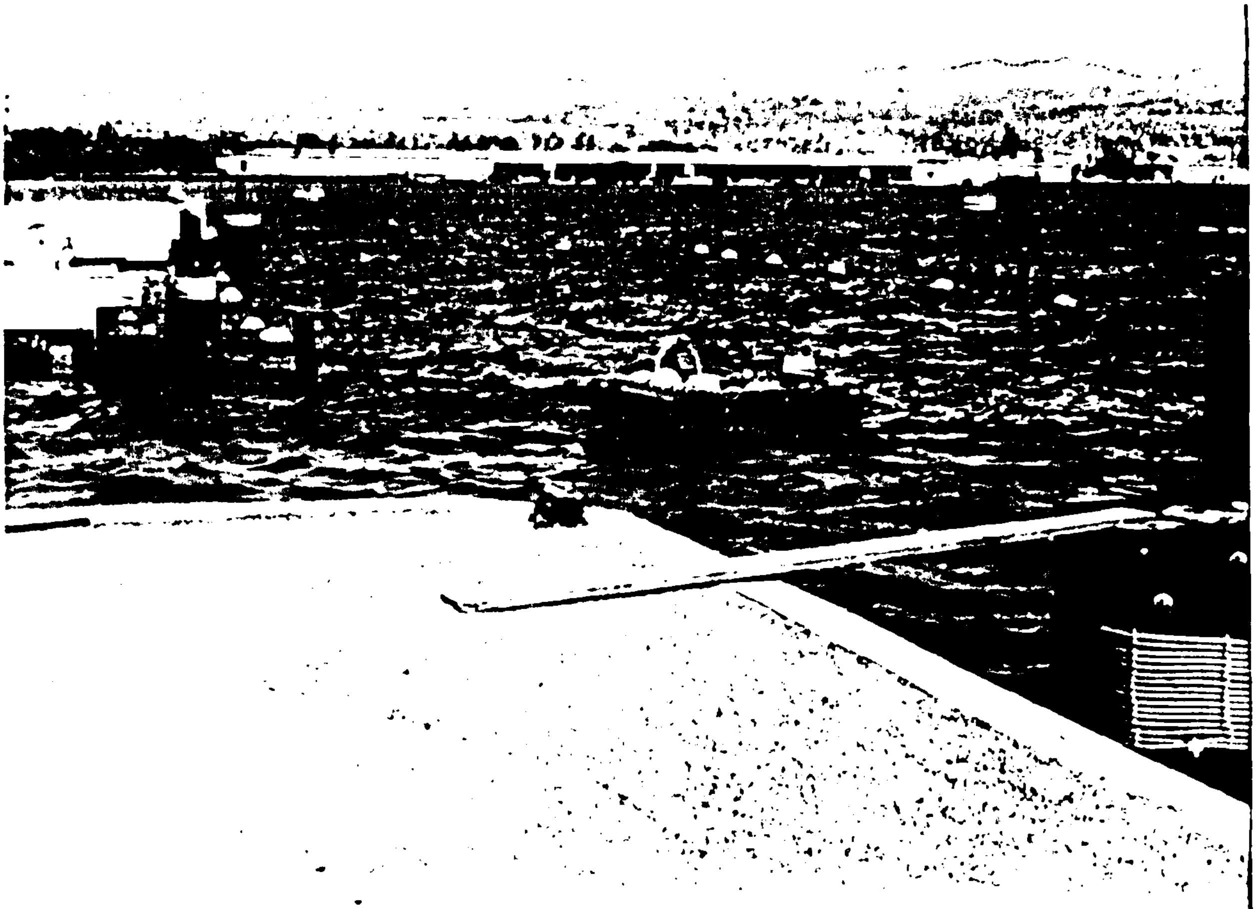
The junction box system was designed to distribute the generated power into the Z-loop cables. A maximum of 120 turns is divided into a system of six parallel loops, each of twenty series turns. Each of three junction boxes contain two of these parallel circuits. The power house delivers up to 4400 amperes at 525 volts, DC, into the Z-loop. There are 12 positive and 12 negative shore feeder cables supplying this power.

The junction box was contractor designed, based on government furnished criteria. The system was to be cantilevered off the south mooring platform of the deperming facility to facilitate cable entry. A stilling well assembly, extending below the boxes into the sea floor, would prevent or minimize cable flexing due to wave and wind action, and would protect the cable



LAYOUT OF INSTRUMENTATION AND GUIDE PILINGS
FOR PEARL HARBOR Z-LOOP REPAIR PROJECT

FIGURE 3-2



TIMBER PILES OUTLINING THE Z–LOOP CONFIGURATION

FIGURE 3–3

from sunlight to prevent insulation damage from ultraviolet radiation.

The junction boxes and stilling wells are entirely of aluminum alloy, with stainless steel connection hardware, to meet both magnetic permeability and corrosion resistance requirements. The corrosion resistance is enhanced by a two coat epoxy finish (MIL-P-24441/1; MIL-P-24441/3) for the boxes, above splash zone, and a Hard-Cote and Teflon finish system for the stilling-well assemblies.

The junction boxes were designed to be watertight in accordance with MIL-STD-108. Cable entrance holes, at the box bottoms, are provided with watertight stuffing tubes to prevent water infiltration.

The bus bar arrangement within the junction boxes was designed to accomplish the interconnection of the Z-loop system to the shore power feeder cables in an orderly, logical, and convenient manner. Individual turns of any of the six parallel coils, in any combination, are disconnectable. All connections and connecting hardware are of copper.

Fabrication and assembly details for the junction box and stilling-well assembly, as initially designed, are completely contained in NAVFAC Drawing Numbers 3026328, 3026329, and 3026330. The major design requirement imposed on the contractor was compliance with "best industry standards (e.g., NEMA, UL, etc., as appropriate)."

JUNCTION BOX COMPONENT REDESIGN

As documented in the Installation Summary section of this report, inspection revealed that the junction box electrical design failed to meet industry code requirements for air gap between live parts, for air gap between live parts and ground, and for surface creepage distances. In addition, the enclosure doors were not substantial enough to insure a watertight seal. It was decided to install the boxes without connecting the system, pending redesign of the crucial electrical components and door assemblies.

The redesigned terminal strips offer somewhat less flexibility with respect to disconnection capabilities, but exceed code requirements for spacing as described above. The redesigned doors also meet code requirements and will assure a watertight seal. The terminal strips and doors, as redesigned, are contained in NAVFAC Drawing Numbers 3026331, 3026332, and 3026333.

JUNCTION BOX INSTALLATION SYSTEM REQUIREMENTS

The junction box site is inaccessible to heavy material handling equipment. Further, limited space was available on the quay for any preinstallation assembly of junction box components. (The specifics of the junction box system are discussed elsewhere in this report.) Hence, both a floating work platform and waterborne lifting equipment were needed to place the boxes. A YC barge provided the large open deck space necessary to lay out and partially assemble the junction box system. A barge-mounted crane then lifted the boxes into position.

4.0 INSTALLATION PLANNING

CABLE INSTALLATION

Some deperming facilities are designed in a slip configuration, with pier support structures located along each side, between which the vessel to be treated can enter. In such facilities, a non-magnetic crib structure is installed around the periphery in which the deperming cable loops can be accommodated. This provides a straight cable path without concern for nonlinear deviations which may affect the uniformity of the generated magnetic field.

In the Pearl Harbor Z-loop, however, the timber piles driven around the circumference serve only as a guide to the cable path. It remained necessary to assure a straight lay, free of meandering curves or kinks, without direct observation of the cable as it dropped through the water column and settled on the bottom. Some observable, controllable, topside parameters would be necessary for quality assurance.

The catenary developed in a cable as it is laid behind a vessel can be considered a function of the tension in the cable deck end and its angle of entry into the water. Both factors are measurable (or estimatable) and can be used to extrapolate the position of the cable on the sea floor.

The installation method initially conceived utilized this concept. The cable would feed off the reel, through a braking device, over a roller on the bow and into the water behind the LCM as it backed around the loop. The braking force would be manually adjustable; the cable angle, as it passed over the roller, could be measured or estimated, and the shape of the catenary predicted. The value of this technique is highly dependent on the ability of the LCM to maintain a straight course at near constant speed. Pitch and roll must be minimized in order to maintain constant tension in the cable. Turns around the corner piles of the loop would also introduce difficulties in control.

An alternative installation technique involved floating the cable on pumpkin type float balloons. Spacing could be set at approximately 30 feet so that only 25 percent of the buoyant capacity of the floats would be required. In the event that one or more floats, secured by a half hitch with slip, came free, the cable could remain near the surface, eliminating

a domino effect which might submerge the floats and cable as a unit. The natural catenary between balloons could be minimized by applying tension on the reel end. With the balloons released, the cable would drop to the bottom, where divers could assure a straight kink-free cable path.

As noted previously, no published PEP exists for this project. Two basic preconceived installation methods are described above. The actual installation first utilized the entry angle method, and evolved into the float balloon technique. Details of the learing curve evolution are included in the Installation Activities, Section 7.0. Modifications of this "around the loop" portion of the installation are also documented therein. Shoreside activity was planned considering that the eventual connection of all the laid cables would be to a set of junction boxes being fabricated concurrently with the loop installation.

The leading end of each cable would be brought onto the south quay with sufficient slack to plumb it over the quay's south edge, and to pull it into position to begin the loop. The cable would be secured to the southwest corner of the quay by rope stopper, with fifteen feet of cable laid out on the quay deck. Designated the Alpha end of the cable, a 500 VDC Megger (insulation tester) would be attached to the bare copper conductor wire at this point. The end would also be labelled for later positive identification.

As conceived, the cable would be guided through a template, fabricated to direct the curve of the cable as it entered the loop. A matching template would direct the return after the loop was completed. The templates were meant to avoid a hopeless entanglement as some 120 pairs of cable ends reached their termination point. However, the templates could not be used; Section 7.0, Installation Activities, later in this report, documents the reasons.

Figure 3-2 shows the installation layout with guide piles as planned. The loop itself passes between the dolphins and quays at both the south and north ends.

The cable would be plumbed over the side and hand-guided to the southeast corner where it would be secured to a quay support pile on the bottom using plastic cable bundle ties. It would be further hand-guided between the dolphins and the south quay. At this point, the LCM would shove off, backing around the loop. The cable would be passed over guide pile 1,

between the north quay and dolphins and around pile 2. The LCM would back around pile 3, for a straight lay to pile 6. It would then turn inboard of pile 7 over which the cable would be passed, and return to the origin.

Upon completion of the circuit, the LCM would again tie up to the south quay. The remaining cable would be reeled off the LCM and faked onto the quay. The cable would be secured by rope stopper at the southeast corner of the quay. Any slack in the loop would be pulled by manpower on the quay and the cable again secured by stopper. As float balloons were released, and as divers worked any slack on the bottom toward the Bravo end, slack would again be pulled to insure a straight cable path on the bottom. With all the slack on the deck, the cable would be guided back to the southwest corner and plumbed over the edge. Fifteen feet would be measured off from this corner to insure adequate lead cable for later junction box connection. Excess cable would be cut off and removed to the catwalk for possible use in the deperming facility's X-loop operations.

Kjellam type grips would be worked over both ends of the cable. Shrink fit caps would be placed over the free ends to prevent moisture intrusion during the interval before tying into the junction boxes. The cable would then be hung by the grips from cable hangers secured to the south edge of the quay.

JUNCTION BOX INSTALLATION

The south mooring platform, designated S20, was built in 1941. The platform consists of 5 feet of copper reinforced concrete, supported on piles, underlying 18 inches of gravel. A 12-inch wide, 18-inch high copper reinforced concrete wall runs the periphery of the platform. The junction boxes were designed to cantilever off the southwest edge of the quay, supported by aluminum channels anchored into the deck. A counterweight, anchored into the main deck of the quay, would itself anchor the channels. The trough created between the counterweight and the wall affords access for the shore power feed cables. The counterweight was sized, and anchor bolts chosen, to support safely the junction boxes, stilling wells, and suspended cable.

After reviewing the plans, PWC PEARL engineers recommended increasing the size of the counterweight and extending the support channels to distribute the load more extensively. The channels were also stiffened and braces added between each channel and the quay side. Details of the counterweight and base system design are contained in NAVFAC Drawing 7463730.

Access for the shore power feed cables was provided through cuts in the quay wall--one 3-foot wide cut in the west wall and three, 12-inch cuts in front of each box location. Figure 4-1 details the platform modifications. Figure 4-2 illustrates the installation.

The initial concept specified a distance of 36 inches between adjacent boxes. This was ultimately reduced to 11 inches to avoid interference with moorings for large vessels.

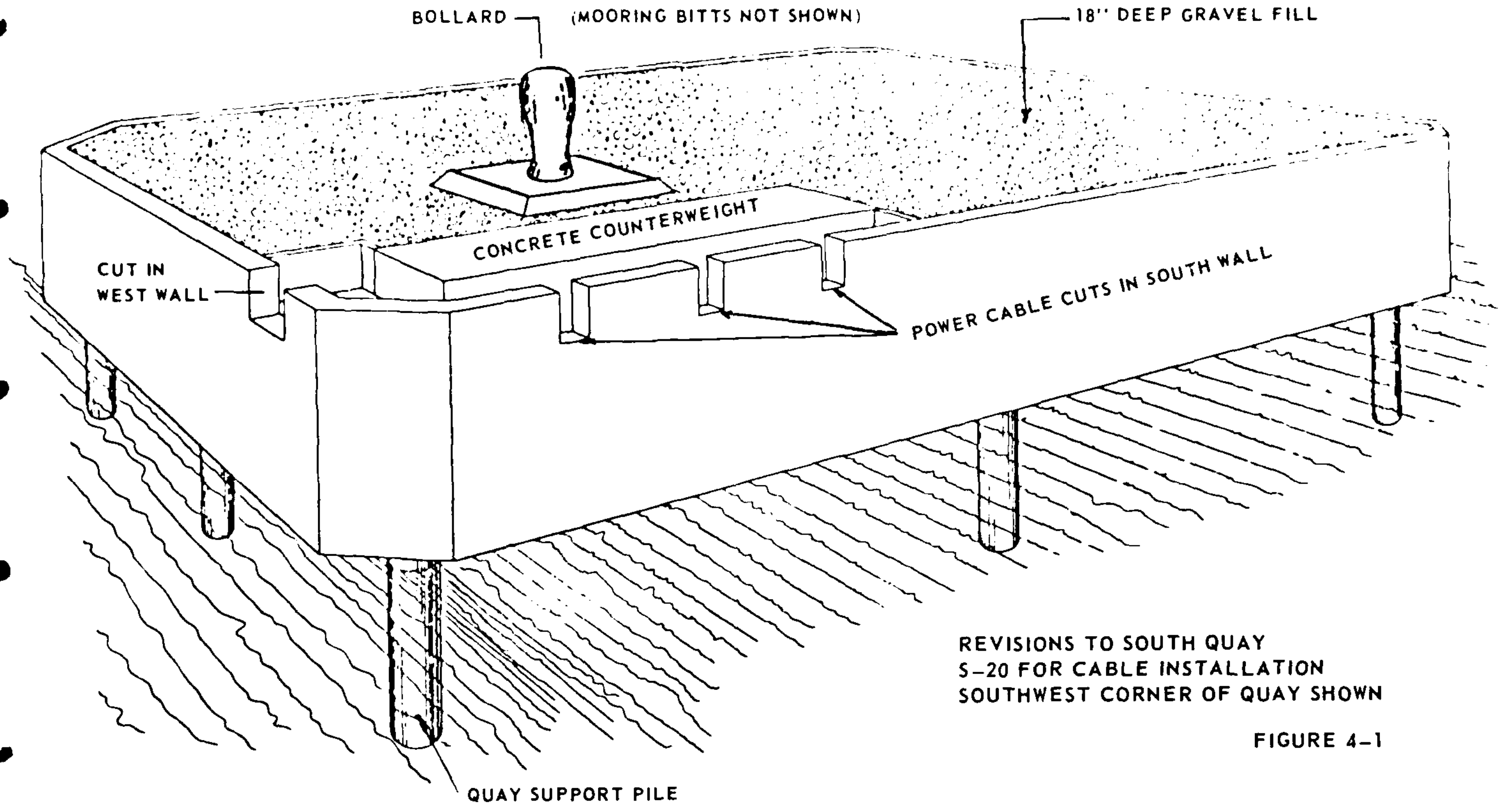
JUNCTION BOX PLACEMENT. The three boxes were shipped assembled from the fabricator. The stilling wells and support channels, however, were not shipped preassembled.

The stilling wells were designed to span the distance from the cantilevered boxes to approximately 3 feet below the mudline. Each well consisted of four aluminum angle, two-segment legs, to which a series of aluminum plates were attached to enclose completely the area below the boxes. Twelve-inch channel sections spanned the legs to form a rigid frame and also to hold a series of cable clamps. A cross-brace further stabilized the shape of the assembly. The extension into the mud line was not intended to support any vertical load, but rather to prevent any slippage of the system away from the quay. Each uppermost leg segment was 10 feet long. The lower section was 5 feet or 10 feet, depending on the depth of water, which drops with distance from the southwest corner of the quay. All the parts bolt together with stainless steel hardware.

Some preassembly could be done on board the YC barge before placing the boxes in position. The upper 10-foot leg sections could be bolted into the boxes, the corresponding channel sections added, and the cross members secured to maintain alignment. The support channels could be shop-welded to the base plates and thus anchored to the counterweight. Anchor bolts also secured the channels directly to the counterweight. By integrating the support channels into the base, the critical spacing between the two channels for each box could be maintained.

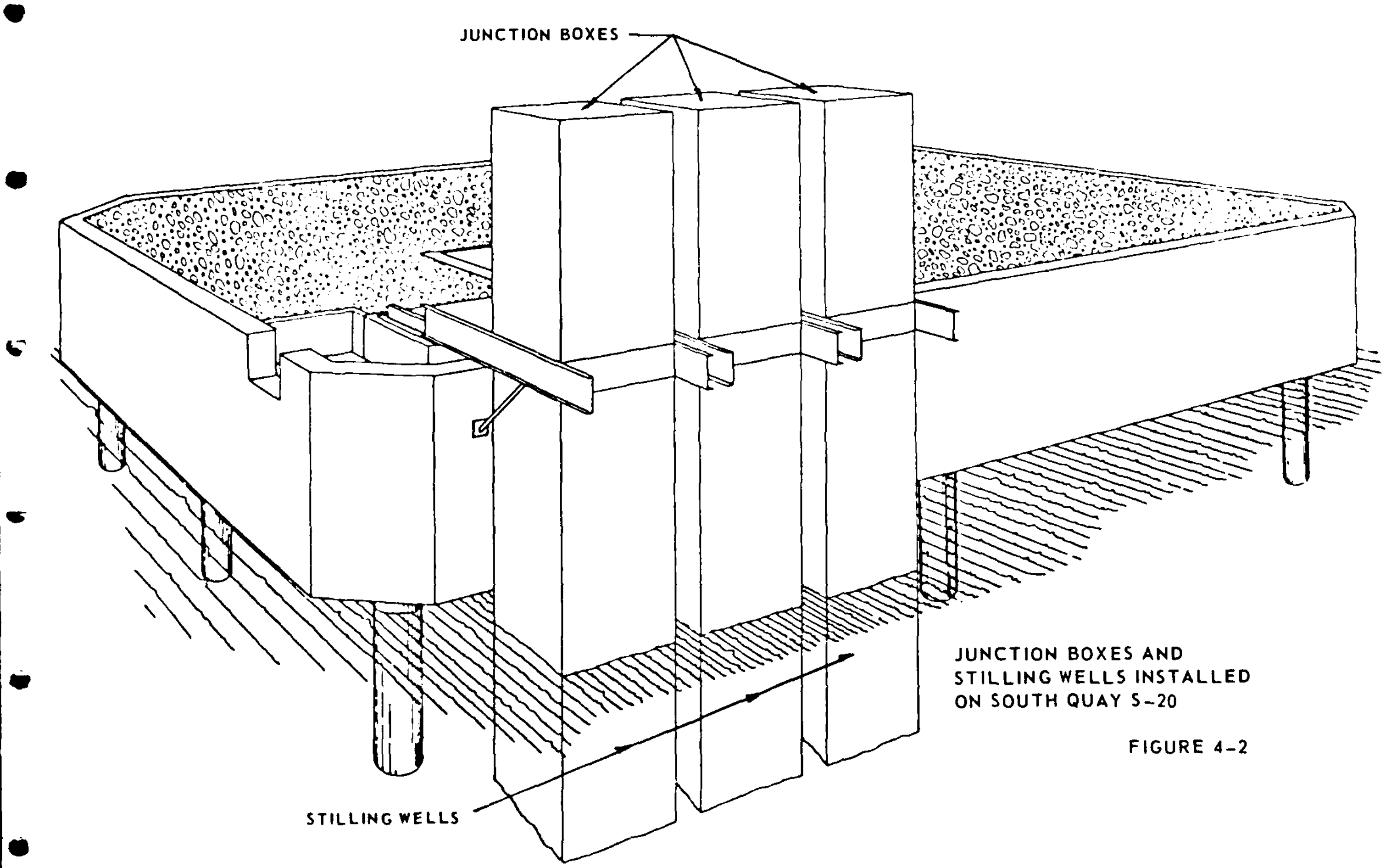
No lifting means were incorporated in the box design. The PWC welding shop could fabricate simple lifting padeyes to bolt into the box framework. Each partial assembly could then be lifted, by barge-mounted crane, into position between its support channels, and bolted into place.

After placing the boxes and upper stilling well components as a unit, the lower leg segments could be attached. To penetrate the bottom, the soft mud could be displaced by diver-directed water jet, while divers guided the



REVISIONS TO SOUTH QUAY
S-20 FOR CABLE INSTALLATION
SOUTHWEST CORNER OF QUAY SHOWN

FIGURE 4-1



JUNCTION BOXES AND
STILLING WELLS INSTALLED
ON SOUTH QUAY S-20

FIGURE 4-2

sections into proper alignment below the joining upper leg. The cross members could be removed to allow cable access and, after all the cables were brought into position, the cross members could be reinstalled. Then, the stilling-well panels could be bolted into the framework.

The panels below the water line could be diver-installed. Those above the water line, up to the box bottom, could be installed by PWC sheet-metal workers working from staging placed around the assemblies.

CABLE CONNECTION. After placing the boxes, and assembling the stilling-well framework, the Z-loop cables would be run from their temporary location at the southeast corner of the mooring platform into their permanent position in the junction boxes.

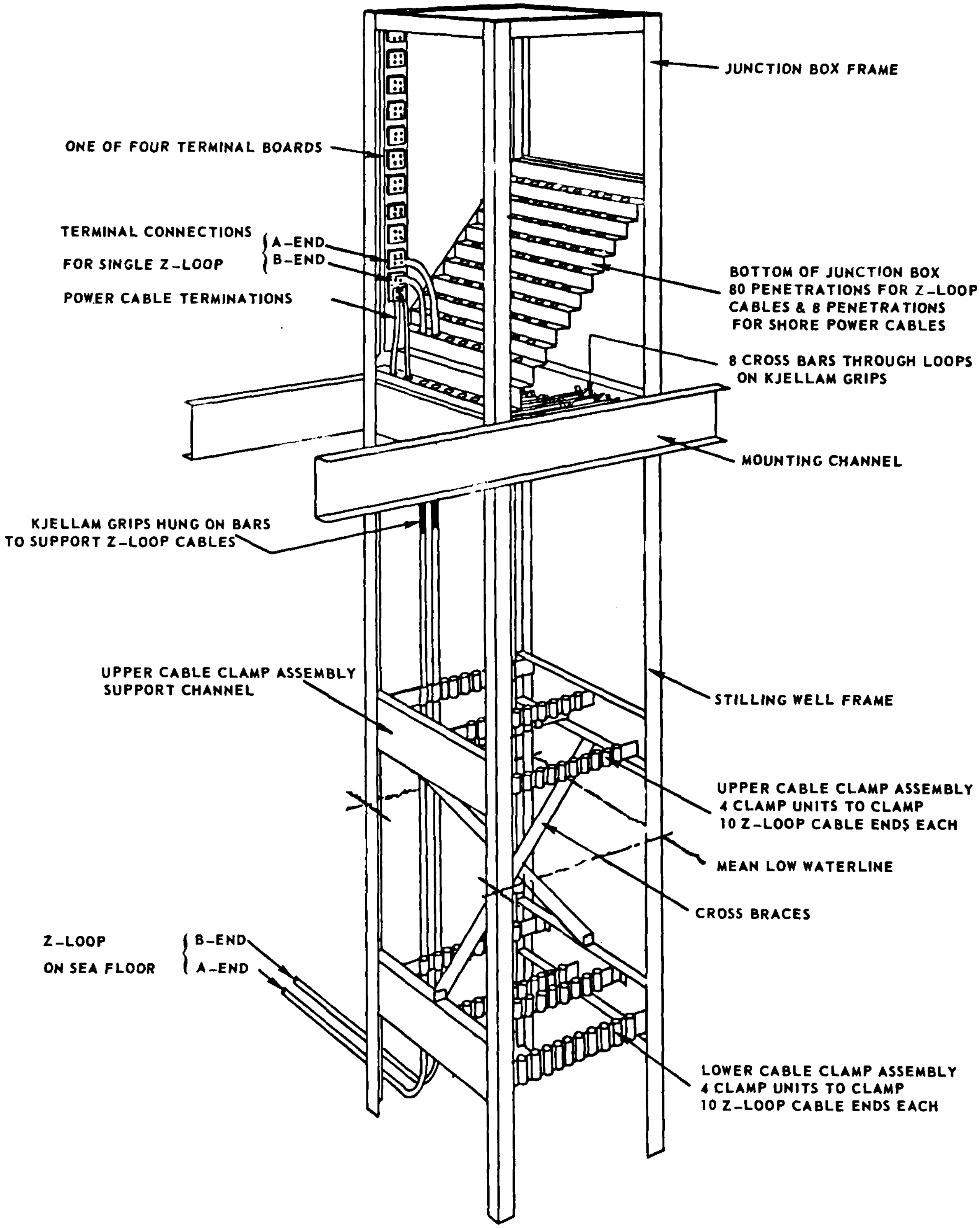
Each pair of cable ends would be removed from its temporary hanger for repositioning in the order of laying. The total number of successfully-laid cables would be evenly divided between the six parallel circuits for uniformity of generated field.

To avoid a rat's nest of cable in the mud at the base of the stilling wells, each cable would be laid along the bottom parallel to the quay and through the framework legs to its permanent position. A cable routed to the first box, for example, would pass between the frames of the third and second stilling wells to its position below the first box.

The cables were to enter the box proper, through holes in its stepped bottom. Each access hole was prepared for cable entry by insertion of a watertight stuffing tube. To maintain an orderly arrangement, the cables would be secured by a clamping arrangement approximately four feet above the bottom. The cables would be hung just below the box level from aluminum bars using the Kjellam grips provided to relieve strain at the terminal end. They then would pass into the box through the watertight stuffing tubes. The cable would be cut to length, lugged and connected to the terminal strip. Figure 4-3 illustrates the cable route from the mud line to the terminal.

Cable pairs would be kept parallel to cancel effectively any magnetic field generated within the box assembly. The routing was planned to avoid any crossing cable paths and provide connections in logical sequence to the terminal strips.

The clamps do not support any of the cable weight, but merely align



Z-LOOP CABLE PATH FROM MUD LINE
TO TERMINAL STRIP IN JUNCTION BOX

FIGURE 4-3

the cables for entry into the box. Each clamp assembly was designed to hold ten cable ends. The clamps were positioned in a two-level, staggered configuration, so that the two ends of each cable would be guided to corresponding positions on each level. Two front half-clamp subassemblies bolt into each back half-clamp securing five cable ends. For easy access, only the two back half-clamps intended for the first ten cables would initially be bolted in.

After releasing the cable from its interim location, the capped ends of each pair would be hand passed through the stilling well framework while divers guided the cable along the bottom in a straight path. The cable would be led on the bottom slightly past its intended location in the clamps and routed back to leave several feet of slack in the cable. When in position beneath the box bottom, the caps would be cut off to allow the cable to pass through the stuffing tubes. After feeding the first several feet through the stuffing tubes, the cable would be meggered to determine its condition. When the cable was vertically aligned between its clamp position and its access hole, the Kjellam grip would be adjusted and slipped over the aluminum bar, securing the cable in place. The identification tags for each pair would be placed on the cable within the box. The cable would then be ready to be cut to size, lugged, and connected to the terminal strip in its predetermined position. This process would continue until all cable pairs were connected.

After each series of 5 cables had been pulled through into the box, the corresponding half-clamp could be bolted into place. With both sections secured, the next clamp back would be secured, etc.

The power-feed cables would be installed last. They were originally routed from the powerhouse, along the entire length of the catwalk, to junction boxes located on the north quay. They would be identified in positive and negative pairs and tied together to prevent mixup. Each pair would be cut so as to leave approximately 50 feet remaining from the south edge of the catwalk. The cable would then be rerouted along the cable trough, through the access hole cut in the quay wall, to the appropriate box. Passing through the corresponding cut in the south quay wall, the cables would be passed through their stuffing tubes, then cut, lugged, and connected to the system.

SYSTEM TESTING

After all the Z-loop and power-feed cables were connected, it would remain necessary to test the system. Of prime concern was the consistent connection of the outgoing and incoming cable ends within each series connection. Should any pair be reversed, it would effectively cancel the field generated by two cables, reducing the system capacity. A final check of the insulation resistance of each cable would be required to serve as a base line for tracking the inevitable cable degradation over time. The system would also be load tested and calibrated prior to actual use in deperming operations. These testing procedures would be carried out by the facility deperming engineer.

5.0 MATERIALS AND LOGISTICS

CABLE AND ASSOCIATED HARDWARE

The Z-loop cable is 500,000 circular mils (500 MCM), 1,225-strand deperming cable conforming to MIL-C-16839 (NSN 9G6145-00-248-4944). The cable is of a special, highly flexible 7 x 7 x 25 rope-lay construction. The individual strand diameter is 0.0201 inches. The overall diameter of the copper conductor is approximately 1-1/16 inches and the overall cable, 1-1/2 inches. The cable is rated for 1,000 VDC working voltage. A maximum current of 4,400 amperes will be delivered to the Z-loop system at 525 VDC. The cables were to be terminated at each end with Burndy (YA39-2LH7) lug terminations for connection in the junction boxes. Minimum continuous lengths of 1,500 feet were specified to assure sufficient cable to complete each individual turn with junction box connection.

The cable was manufactured by two concerns. Seventy reels were produced by Pirelli Cable Corporation, Union, NJ, procured through Industrial Components, Inc., New York, NY, and supplied by Hatfield Wire and Cable Company, Hillside, NJ. Forty-six reels were produced by Tara Company, Bethlehem, PA, and supplied by Carol Cable Company, West Compton, CA.

Two additional reels of Pirelli cable, initially procured for X-loop cable wraps and less than 1,400 feet continuous length could be used in the Z-loop installation by splicing on an additional length sufficient to complete the loop. Thus, a total of 118 cables were available for upgrade of the Pearl Harbor Z-loop.

Some eighteen of the Tara reels were badly deteriorated and could not safely be used to unreel cable from the LCM. These were re-reeled onto empty spools by laying the bad reels on a turntable, unreeling onto an intermediate reel on a powered reel stand, and rewinding onto sturdy, empty reels from earlier Z-loop turns.

The existing feed cable is 500 MCM, 37 strand, single conductor construction. The individual strand diameter is 0.1162 inches. The existing feed cable would be reused, being rerouted to the new junction boxes. The cables were to be terminated with standard 500 MCM sleeved lug terminations for connection in the junction boxes.

OTHER FABRICATION

Three cable hangers, from which the cable ends were hung for the interval before connection into the junction boxes, were fabricated by PWC PEARL from specifications supplied by CHESNAVFACENGCOM. Cables were secured by shackles through the Kjellam grip beckets and holes in the hangers.

Two cable templates were designed by VSE Corporation, Alexandria, VA, based on specifications supplied by CHESNAVFACENGCOM, and fabricated by Custom Metals Fabrication Inc., Kingsford, MI.

The junction boxes were designed by VSE Corporation based on specifications supplied by CHESNAVFACENGCOM. After approval of the design drawings, fabrication was completed by Custom Metals Fabrication, Inc. The redesign for the terminal strips and enclosure doors was done by VSE Corporation with fabrication by Custom Metals Fabrication.

Miscellaneous fabrication tasks, including LCM deck preparation, A-frame assembly, turntable for re-reeling cable from unsatisfactory reels, and float balloon harnesses were performed by UCT-TWO personnel.

OTHER MATERIALS

Kjellam type grips, heat shrink caps, and aluminum identification tags were supplied through UCT-TWO. Diving gear and associated hardware, float balloons, line, radios, and a Zodiac inflatable boat, all with pertinent repair and maintenance equipment were also UCT-TWO supplied. Vessels and construction equipment were provided as outlined in Section 2.0.

TRANSPORTATION AND STAGING

Shipment of the cable reels to Pearl Harbor occurred over two months prior to the project start date. Temporary storage was provided at the deperming facility, where, exposed to the elements, a number of reels became infested with termites in addition to deterioration through exposure. The deperming facility, consisting of the three quays and wooden catwalk, could not support heavy material handling equipment; hence, direct loading of the LCM from within the deperming facility was not possible. The most efficient means of loading the reels on the LCM was a ship-to-ship transfer afloat. The cable was moved to Ford Island, where it was stored in a warehouse pending

start of the project. From Ford Island, a YC barge was loaded by crane with 71 cable reels. The barge was towed to a mooring buoy just south of the Z-loop site. From this point, reels could be loaded aboard the LCM by the cherry picker installed on the barge. Empties could be offloaded and four full reels could be placed on jackstands aboard the LCM in 30 minutes. After handling the initial barge load, the barge was towed back to Ford Island, the empty reels offloaded, and the remaining cables put on board.

Equipment borrowed from or leased by the Ocean Construction Equipment Inventory (OCEI), maintained by FPO-1, was shipped from Portsmouth, VA, and Port Hueneme, CA, via Matson Lines surface transport. OCEI material and logistics support were provided by Tracor Marine Inc., Port Everglades, FL.

Materials and equipment supplied by or procured through UCT-TWO were packed in CONEX boxes for delivery to the deperming facility. Equipment needed during project execution, including additional float balloons and a Zodiac inflatable boat, were air-shipped for expeditious delivery. The cable templates were air-shipped directly from the fabrication point to Honolulu Airport for pickup by UCT-TWO personnel. The junction boxes and associated hardware were shipped from Kingsford, MI to Oakland via truck, and trans-shipped to Pearl Harbor by surface ship utilizing the Navy "Surface Express" system; redesigned components were sent by air freight.

ADDITIONAL CONSIDERATIONS

Manpower, in addition to that provided by UCT-TWO, CHESNAVFACENGCOM, and MSF personnel, was obtained through the First Lieutenant Department, NAVSTA PEARL. That department provided two to four men on weekdays to help man the LCM and provide additional shoreside support.

Other materials, as required, were procured through SERVMART.

6.0 INSTALLATION PREPARATIONS

The installation methods discussed earlier became the basis for the Z-loop upgrade installation activities. As the project team gained experience in handling the cable, the procedure became more streamlined. The preparations for installation occurred during August and September 1982; installation activities are then documented chronologically covering the period from September 1982 to June 1983.

ADVANCE PARTY PREPARATIONS

An advance party from UCT-TWO deployed to the site on 23 August 1982, and the main body arrived on 30 August for a total of 11 divers comprising *Detachment Pearl Harbor*. Two CHESNAVFACENGCOM FPO-1 engineers arrived on site to prepare for project initialization on 9 September. (A third FPO-1 engineer arrived 16 September in support of the cable-laying operation.)

A diver inspection was conducted to determine existing conditions within the Z-loop site, including location of the old Z-loop instrumentation, bottom conditions, and visibility. It was found that south of the south quay, a massive outcropping of coral rock projects into the intended straight cable path. From a depth of 40 feet, the bottom rises to just 10 feet below the surface and then drops back to 35 feet. Innumerable instrument cables are suspended across this outcropping which would hinder the current operation. The Z-loop could be laid up and over the outcropping or detour slightly around the formation to keep the loop at a more consistent depth. The latter course was chosen.

The bottom consisted of very soft silt with shell and coral fragments. Visibility ranged from under one foot to three feet. Disturbing the bottom reduced visibility to virtually zero. Marker buoys were deployed to mark the location for driving guide piles, set to outline the intended loop periphery.

GUIDE PILES

Eight, seventy foot-long timber piles were supplied by PWC PEARL to Hawaiian Dredge and Construction, the pile-driving contractor. Pile position was checked by transit, and position and verticality were checked by divers

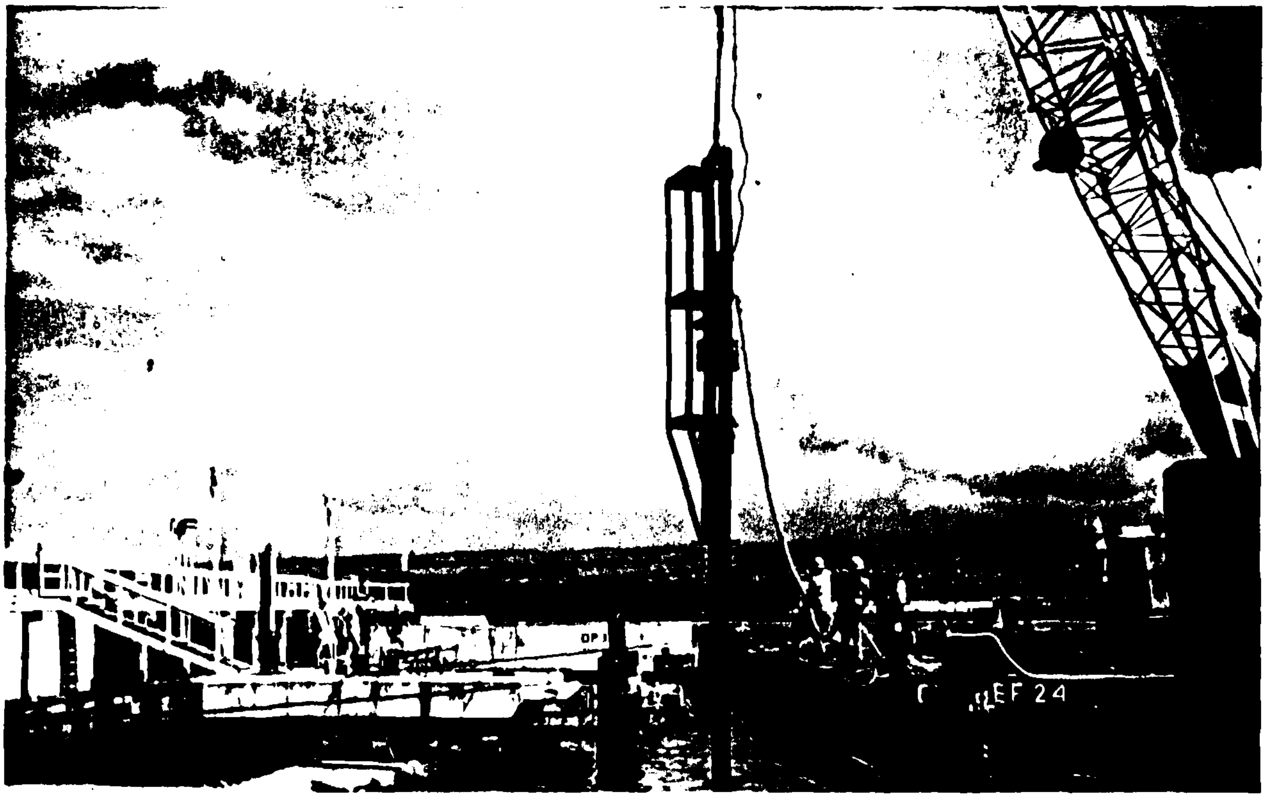
during the operation. As these were guide piles only, no bearing capacity was necessary nor was it predetermined. This was fortunate, as hammer weight alone was sufficient to penetrate the soft bottom in one case, and very few hammer blows were necessary for most piles. The piles were installed on 14 and 15 September; they are identified by number in Figure 3-2. Figure 6-1 shows the pile-driving operation.

VESSEL PREPARATION

The deck of the LCM was fitted with 8" x 12" timbers to distribute the deck load and to which six sets of reel jacks were secured in two rows of three each. Figure 6-2 illustrates the cable reels mounted on jack stands. The braking device was secured forward of the reel stands. Rollers were welded to the bow in line with each row of reel stands, through which the cable passed to prevent chafing. After the first day of operation, the braking device and rollers were replaced by an A-frame off the bow, fabricated on site by a UCT-TWO steelworker. A Sherman-Reilly 36-inch aluminum snatch block was hung from the A-frame through which the cable passed. Two sets of reel stands were removed.

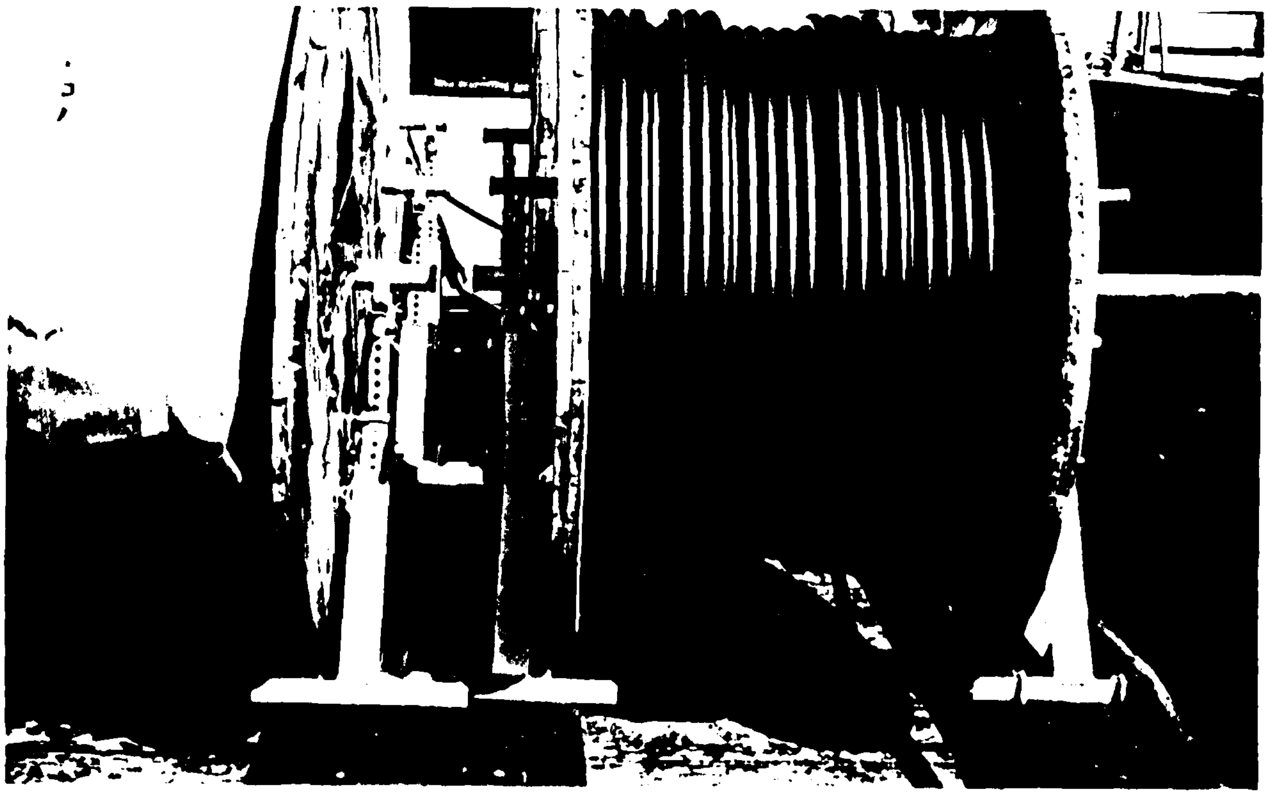
A pier-based crane loaded the cherry picker type crane onto the YC barge at Ford Island. Sufficient timber shims to secure a full load of reels also were placed on the barge.

An LCVP served as the diving platform throughout operations. The bow ramp afforded ease in entering and leaving the water for divers and swimmers. Additionally, a Zodiac inflatable boat was used to recover float balloons, and to apply tension to remove slack from the loop as needed.



DRIVING GUIDE PILES FOR Z-LOOP PERIPHERY

FIGURE 6-1



CABLE REELS ON JACK STANDS

FIGURE 6-2

7.0 INSTALLATION ACTIVITIES

Z-LOOP CABLE INSTALLATION

Operations began the morning of 18 September 1982. The cable template was lowered into place at the southeast corner of the south quay. The divers indicated reservations about the stability of the template due to a steep slope of the bottom at this position.

A dry run to familiarize the LCM operator with the cable-laying course was performed immediately prior to handling the first cable. The large sail area of the LCM made handling difficult, particularly at guide pile #6.

The first cable was secured on the south quay at 0840 hours on 18 September. Two men turned the reel, two men pulled the cable as it left the reel, and a fifth man handled the braking device. The entry angle was monitored while the LCM backed around the loop. Tension was applied as consistently as possible. The onboard CHESNAVFACENGCOM engineer noted difficulty in negotiating the turns, while maintaining tension with the braking device. The straight course portions of the loop were smoothly completed although the LCM was as much as 8 feet east of piles #4 to #6. Transitting the loop required 65 minutes. The bitter end was landed and excess cable cut off.

Divers then swam the loop inspecting the first cable. They found the cable to be very tight, particularly at the guide piles. This excessive tension had prevented the cable from dropping to the bottom as intended. Instead, the cable turned the corners more than ten feet above the bottom, hung up there by the tension in the cable and friction against the piles. The divers were unable to manhandle the cable to the bottom. The cable laid on the bottom adjacent to the south quay was pulled taut as the LCM backed away. The eastern, straight portion of the loop was displaced up to ten feet from the intended path. A decision was made to retrieve the cable. An inspection revealed that the cable template had shifted down the slope near pile #8. Due to this instability, and the fact that the template was not critical to the upgrade, it was decided to retrieve the template as well. The template was lifted to the surface by float at 0800 hours 20 September and the cable, identified by its end as 1A and 1B, was retrieved by manually pulling the cable from the bottom, and winding it back onto the reel as the LCM traversed the loop in a reverse direction.

For the second attempt, the braking device and bow roller were replaced by an A-frame off the bow, with an aluminum snatch block over which the cable passed. From the sheave, the cable passed into an eighteen foot boat where float balloons could be secured. By floating the cable, the excessive tension at the turning piles could be avoided. The cable was secured to pile #8 and to a support pile beneath the south quay to avoid suspending the cable. Before reaching the first turn, however, the megger reading (which was continuously monitored) dropped to zero, indicating a fault in the insulation where the cable entered the water column. The point at which this occurred was marked, and the cable retrieved by rewinding the payed-out cable back onto the reel. An apparent manufacturing defect was located at the marked area.

On the third attempt, the loop was completed without incident. Thirty-five float balloons (each with a 250 pound lift capacity) were secured to the cable beginning along the north segment at pile #2. The floats were released and the cable dropped to the bottom.

Cables 4 and 5 were deployed together, the first and only attempt at a multiple cable lay. Because the cables were fed from two reels, it was difficult to coordinate the application of tension or the release of slack with the tying of floats. It was also realized that in the event one cable in a multiple lay should be faulted, it could not be readily retrieved. In addition, the time required to complete the loop was more than twice that of the previous successful single lay. No further multiple lays were attempted. Two more cables were laid that afternoon.

On 22 September, divers inspected the five cables on the bottom. They reported excessive slack, loops and irregularities when they walked out toward the Bravo end. The slack generated by this procedure was pulled out on the south quay. Megger readings taken after this operation showed cables 3, 4, and 5 had grounded out. It was speculated that the additional handling may have aggravated weaknesses in the insulation, resulting in water intrusion.

The cause of the non-uniformities was analyzed before proceeding with additional cables. The float balloons were being released too quickly and out of sequence. This allowed curves and kinks to develop as the cable fell to the bottom. To remedy this condition, a single swimmer was directed to

release the floats in sequence, allowing sufficient time for each segment to fall to the bottom before proceeding to the next float.

Floating the cable vastly improved the efficiency of the operation. Floats were attached from the center quay around the remaining loop beginning with cable 8, then increased to include the entire course starting with cable 16. Then, when manually guiding the cable between the north quay and dolphins, the slack could be pulled out of the west edge. From a camel off the north quay, the cable was passed over pile #2. The LCM would then back northward, paying out cable and floats. With sufficient cable behind it, the LCM could swing on this cable radius, and turn around piles #2 and #3. At the southeast edge (pile #6), slack was pulled by the boat crew by laying back on the cable while the LCM slowly moved back, and then swung around the pile. It was necessary to pass inboard of pile #7 due to shallow water on the outside of the pile. The cable was passed over pile #7, and the LCM backed in toward the south quay, completing the loop. Any remaining slack was pulled from the quay. The shoreside crew would then ready the next cable for laying. Plumbing, cutting, capping, and hanging could then be completed while the next lay proceeded.

Figures 7-1 through 7-5 illustrate the installation process.

The log of cable installation is included as Appendix A. A total of 118 cables were handled, two of them (1 and 37) were handled twice, for a total of 120 operations. Of these, 105 good cables were laid. Nine cables had insulation faults, which resulted in water intrusion, and were retrieved in the manner previously described for cable 2. Three cables became faulted after laying -- these were cut free and abandoned-on-site. Cable 1, which had been retrieved because it was too tight, was lengthened by splicing a length of excess cable to its end. The splice (3M Company molded resin cable splice) failed, however, and the cable was re-retrieved. Two other short cables were lengthened by splice without incident.

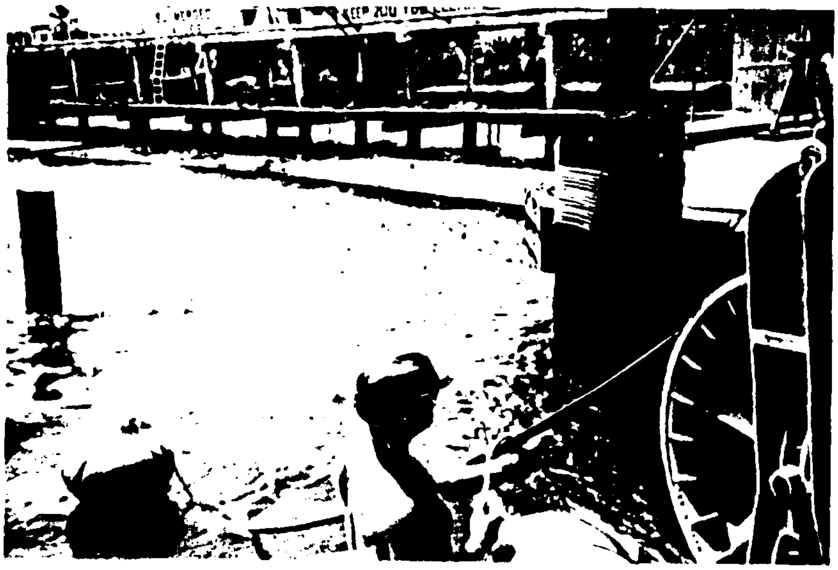
The 105 cables installed totalled over 23 miles in length.

Diver inspection showed little deviation from the intended loop configuration; the cables generally formed a bundle only 36 inches wide. As a result, a uniform magnetic field will be generated.

The guide piles were cut off just above the cable bundle utilizing an underwater chain saw following completion of the cable-laying phase.

LCM PIVOTING
AROUND PILE #3

FIGURE 7-1

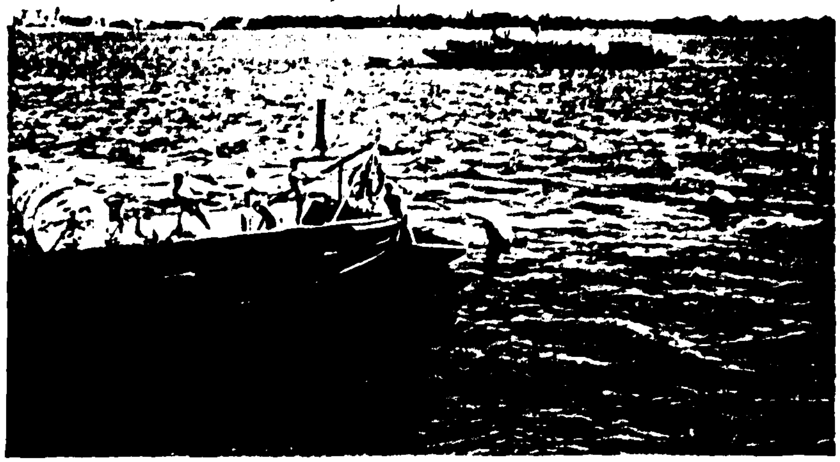


TYING FLOAT BALLOONS
TO CABLE

FIGURE 7-2

PASSING CABLE
BEHIND DOLPHIN
AT NORTH QUAY

FIGURE 7-3



ROUNDING PILE #7
CREW HAULS BACK ON
CABLE-REMOVING SLACK

FIGURE 7-4

BACK AT SOUTH QUAY -
RETURNING BITTER END
TO COMPLETE LOOP

FIGURE 7-5

PULLING SLACK ON
SOUTH QUAY AS
FLOATS ARE RELEASED

FIGURE 7-6

INSTRUMENT REPLACEMENT AND SURVEY

During the site survey it was noted that a plethora of instrumentation cables crossed through the old Z-loop cable path. It was anticipated that some number of functioning instruments would be put out of commission during the upgrade project. It was agreed that UCT-TWO divers would replace any magnetometers grounded during the operation. Time permitting, ancillary tasking included surveying the locations of all existing instrumentation tubes.

It was necessary, during the cable laying, to cut away three instrument cables to lay the deperming cables properly. None of these was a live instrument cable. Two live instruments were grounded as a direct result of the Z-loop upgrade.

The magnetometer array was surveyed on 20-27 October 1982 to document the location and elevation of existing tubes. The array consists of seventy vertical copper tubes installed in the sea floor with magnetometer probes hanging in them below the sea floor level. Each probe is connected to the catwalk pier with an individual underwater cable. Twenty-two tubes have two probes installed for a total of 92 probes, Figure 3-2.

In addition to the two instruments that were grounded during the Z-loop installation, twelve instruments previously grounded were retrieved, refurbished, and replaced during the survey. The survey data were handed over to the facility as an updated array record.

JUNCTION BOX INSTALLATION

PWC PEARL accepted tasking for shore-based installation of the junction boxes and stilling wells and connection of all cables. MDSU-ONE agreed to perform all necessary underwater construction. Due to fleet operational commitments, the installation had to be completed, checked out, and operational prior to 7 February 1983.

COUNTERWEIGHT CONSTRUCTION. Excavation for, and construction of the concrete counterweight was completed on 21 December 1982. PWC PEARL had initially agreed to complete this preliminary step in early December. In late November, however, before work was to begin, Hurricane Iva struck the Hawaiian Islands, forcing PWC PEARL to devote all available personnel to disaster recovery. It was decided to award an informal contract to construct

the counterweight to meet the time constraints.

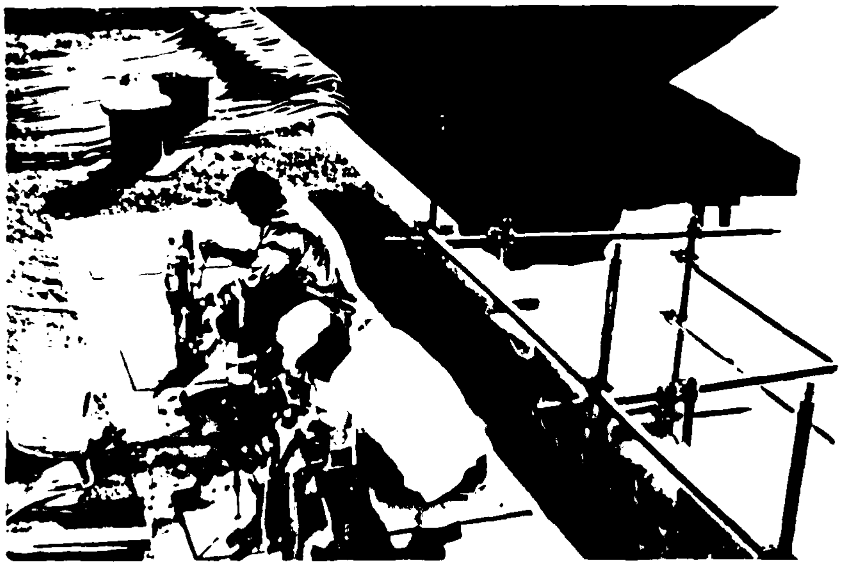
The concrete counterweight was poured on 21 December 1982, under Construction Contract N62471-83-C-2035, based on NAVFAC Specification No. 14-83-2035 and accompanying Drawing No. 7463703. The work was specified to be in accordance with the best current industry standard. The completed counterweight was approved by a PWC inspection with no CHESNAVFACENGCOM representative on site.

The CHESNAVFACENGCOM technical representative arrived on site 3 January 1983 to inspect the initial work and coordinate the installation. Most obvious was the failure of the contractor to excavate the existing gravel material as indicated in the contract drawing. Excavation had only been done for the counterweight itself,not for the adjacent cable trough. In addition, the counterweight was not level in either direction, nor with respect to the quay wall, as indicated in the drawing. It would be necessary to shim the base plate system for level installation of the boxes, or pour additional concrete to correct the problem. The severe time constraints precluded any additional concrete work with its ensuing curing time. That morning the situation was discussed with the Naval Station Assistant Operations Officer and PWC masons to determine remedial action. Use of a free-flowing epoxy shim could readily correct the counterweight slant. On 9 January, the contractor returned to the site to excavate the cable trough in accordance with requirements.

SITE PREPARATION AND MATERIALS TRANSPORT. With the counterweight in place, preparation for the setting of the base plate system began on 10 January 1983. PWC masons laid out the locations for the cable access cuts in the quay wall. Masons also chipped out the top one inch of the south wall in front of the counterweight to bring it approximately level with the counterweight. The access holes were cut by National Saw Cutting on 14 January. Only vertical cuts were made in the south wall to avoid weakening the wall on which the support channels rest. This weakening would result from the overcut necessary with the circular cutting blade penetrating the full depth of the wall. The cuts were deeper on the outside surface of the wall for the same reason. Figure 7-7 shows the saw cutting in process. The material could then be readily knocked out of the cuts and hauled away. The trough bottom and wall cuts were smoothed and sloped to allow drainage. The quay wall was also patched in the chipped area and CMU walls were built at the ends of the trough.

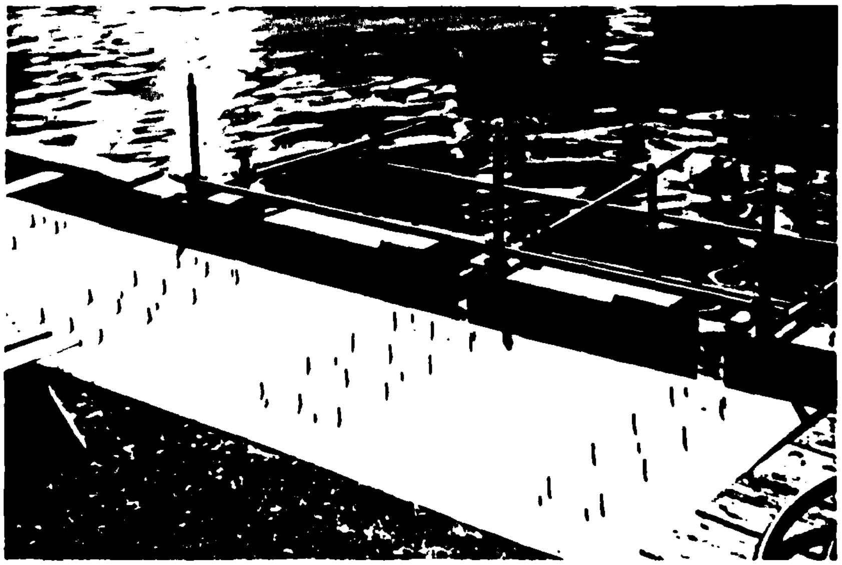
CUTTING POWER FEED
ACCESS HOLES

FIGURE 7–7



PREPARING COUNTERWEIGHT
FOR SUPPORT CHANNEL BASE

FIGURE 7–8



CONCRETE COUNTERWEIGHT
READY FOR BASE PLATES

FIGURE 7–9

The PWC welding shop fabricated a set of templates as a guide for the drilling of holes for the anchor dowels fastening the base plate assembly to the counterweight. The templates were shimmed with steel spacers to bring them to level. The drilling was completed and the dowels set with epoxy on 16 January. Figures 7-8 and 7-9 show the counterweight and access holes.

The base plates, channel guides, and pipe supports were all fabricated in the PWC welding shop. Fabrication was completed and all surfaces treated and primed on 17 January.

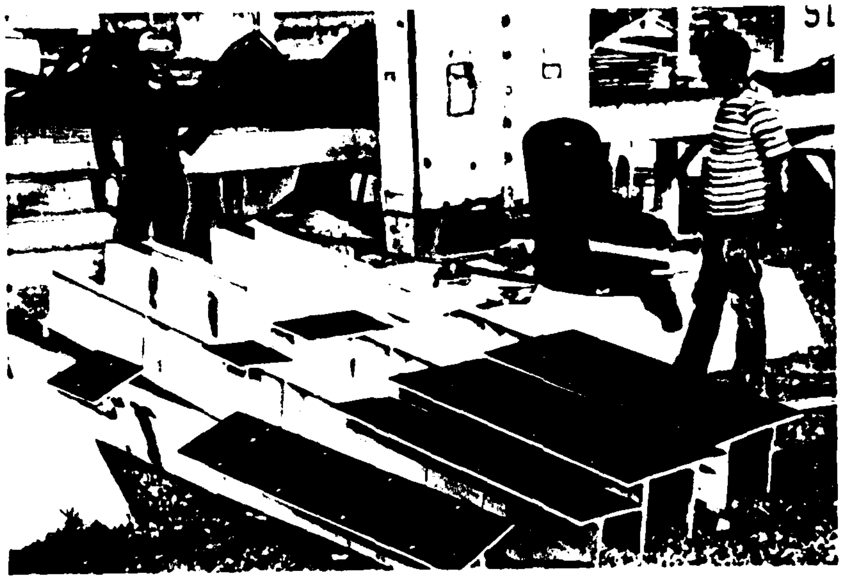
The Naval Station wharfbuilder's barge crane was available 18-22 January prior to a scheduled maintenance period. The long boom of this crane would allow it to reach the box site from outboard of the YC barge on which the junction boxes were staged. The base plates, etc., were placed aboard the barge crane and transported to the facility south quay on 18 January.

The crane was used to offload the materials onto the quay deck. The base bottoms and all other surfaces, which would be inaccessible after installation, were coated with the specified epoxy based paint. Neoprene rubber pads were cemented to the bottom surfaces to isolate the metal from the concrete and damp out any vibrations which might loosen connecting nuts. Figure 7-10 shows the base prior to placement. The base system was placed the morning of 19 January.

The junction boxes and stilling wells were shipped to NAVSTA PEARL in a container consigned to the Pearl Harbor Naval Shipyard. The container was released for unloading on 5 January 1983. The material was transferred to a YC barge for transport to the deperming facility. During the unloading operation, it was noted that considerable damage to the epoxy coating system was evident. This was probably caused by chafing from dozens of wooden battery racks stacked on and packed around the boxes for shipment in the same container. The barge was moved on site on 6 January and tied up at the south platform.

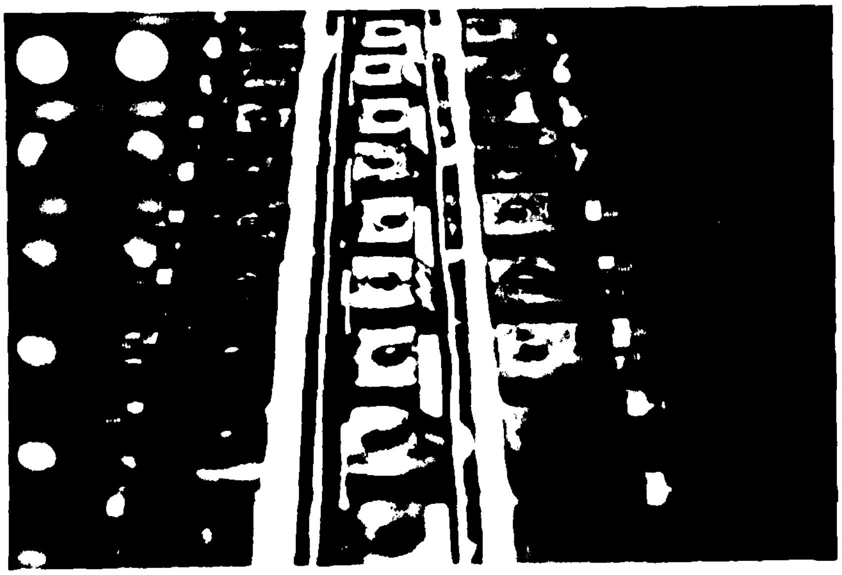
That afternoon, the CHESNAVFACENGCOM representative, the deperming officer, the deperming engineer, and the facility electrician unstrapped the boxes for internal inspection. All copper surfaces, specified to be silverplated, were green and felt greasy to the touch. The plating operation had not been done correctly, as illustrated in Figure 7-11.

This information was forwarded to the CHESNAVFACENGCOM office and



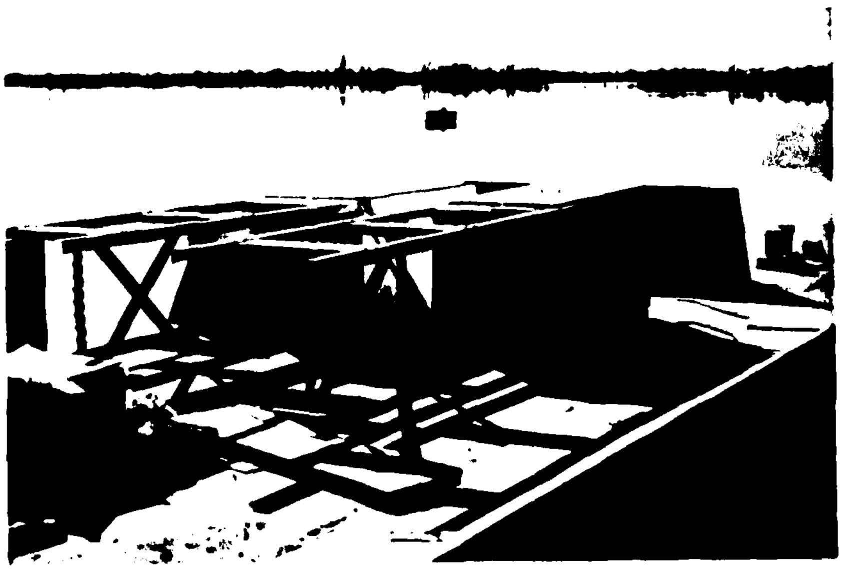
BASE PLATE/CHANNEL
SUPPORT SYSTEM
PRIOR TO PLACING

FIGURE 7-10



ORIGINAL SWITCHING MATRIX
SHOWING PLATING AND
SPACING PROBLEMS

FIGURE 7-11



PARTIALLY ASSEMBLED BOXES
STAGED ON YC BARGE

FIGURE 7-12

discussed with the design contractor. Resolution was deferred until the arrival of the contractor's representative on 12 January. At that time, it was determined that all copper contact surfaces needed to be cleaned and replated properly.

JUNCTION BOX AND STILLING WELL FRAMEWORK. PWC sheetmetal workers bolted the topmost 10 foot stilling well framework legs into the junction boxes on 12 January. The cross braces, channel sections, and two back half-clamp pieces were also fastened to maintain the framework alignment during lifting and placement of the boxes. With preassembly complete, placement of the boxes was delayed awaiting completion of site preparation. Figure 7-12 shows the partially assembled boxes staged on the YC barge.

On 13 January, the deperming facility electrician expressed his concern about clearances between parts and the gaps left by the fit of certain Teflon insulation. In agreement, the deperming engineer was considering calling the Underwriters' Laboratory to approve/disapprove the electrical switching assembly. The CHESNAVFACENGCOM and contractor representives checked the "as-built" clearances against those specified in the fabrication drawings. Although the drawings called for 3/8-inch clearance between particular parts, actual clearances varied from 3/8-inch down to 3/16-inch in some cases. Considerable machining would be necessary to bring the clearances to specification. The deperming engineer indicated the 3/8-inch gap was insufficient to meet National Electrical Code (NEC) requirements. For the applied voltage in this case, the NEC specifies a 1-inch gap through air and a 2-inch gap across creepage surfaces.

This information was forwarded to CHESNAVFACENGCOM for discussion with the contractor. The contractor contended that the design specifications were adequate. Based on this advice, the installation continued with the expectation that the required machining could be completed and the system installed within the requisite schedule. The terminal strips were removed from the junction boxes for disassembly to make the necessary corrections.

POSITIONING THE JUNCTION BOXES. With site preparation complete, the boxes were placed in position on 19 January. Lifting eyes, lacking in the original design, were bolted into the corners of each box. The center box, designated Box 2, was the first lifted, at 0930 on 19 January. The harbor was glassy still on that morning which facilitated control of the lift.

Figures 7-13 and 7-14 show the operation in progress. The lift was accomplished without incident. When the box was brought between the channels, it was found that bolt heads on the east and west sides, holding the leg sections to the box, could not clear the channels. The offending bolts were removed and the box dropped into place, after which these bolts were replaced.

Each corner of the boxes was designed to connect to the support channels by a pattern of three bolts accommodated by helicoil inserts set into the box frame. When the boxes were placed on the channels, the deformation caused by box weight misaligned the hole patterns somewhat making the connection difficult. Of the 36 such bolts, three could not be secured due to this misalignment. For added safety, a fourth bolt was added to each corner by match drilling through the channel and box framework after setting the boxes.

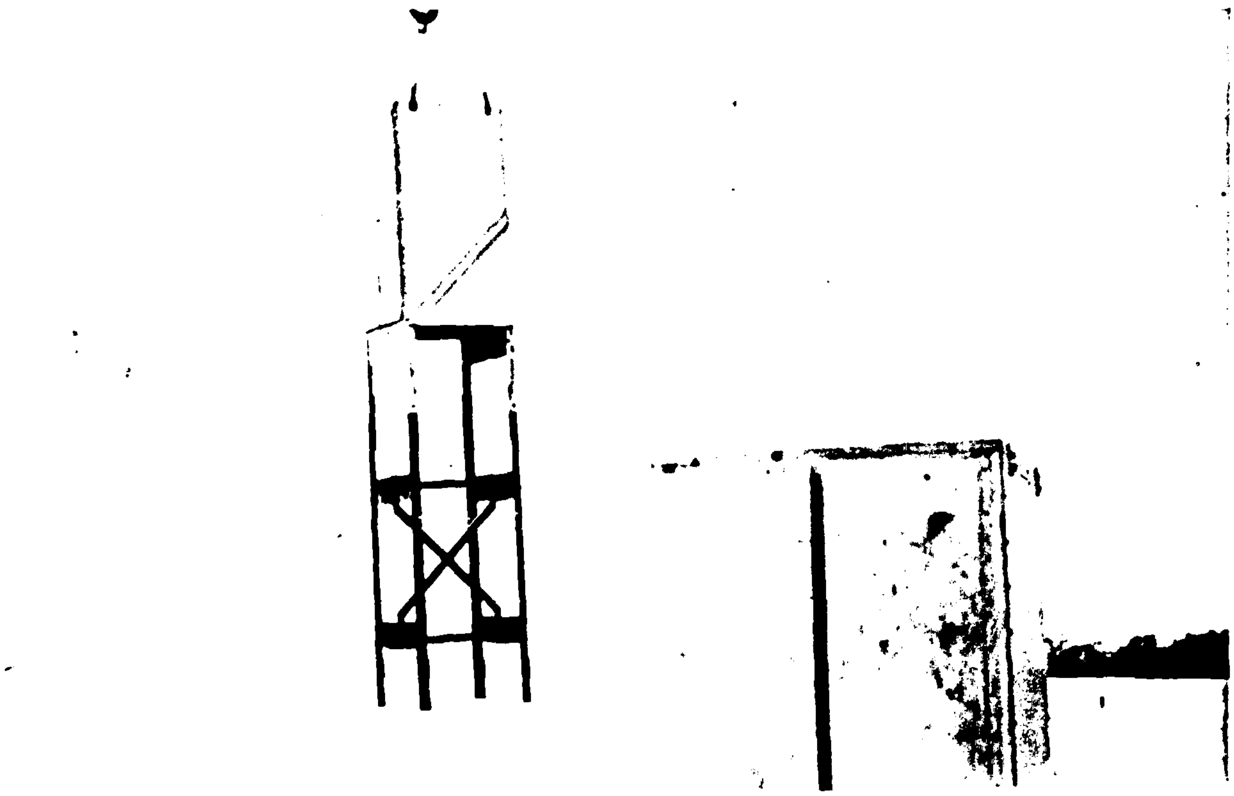
The three boxes were all in place at 1330, 19 January. For aesthetic reasons, the lifting eyes were removed and the original bolts replaced.

At the request of the facility, a PWC electrical inspector visted the site on 19 January to investigate the electrical switching system for code compliance. The next morning, having reevaluated the code requirements, the contractor initiated investigation of a design modification which would bring the existing hardware up to code. Again, the installation continued with the now fading expectation that the system could be operational on schedule.

INSTALLATION OF THE STILLING WELLS. Divers attached to MSDU-ONE arrived on 20 January to complete assembly of the stilling wells. They were part of a Naval Reserve Unit out of San Francisco.

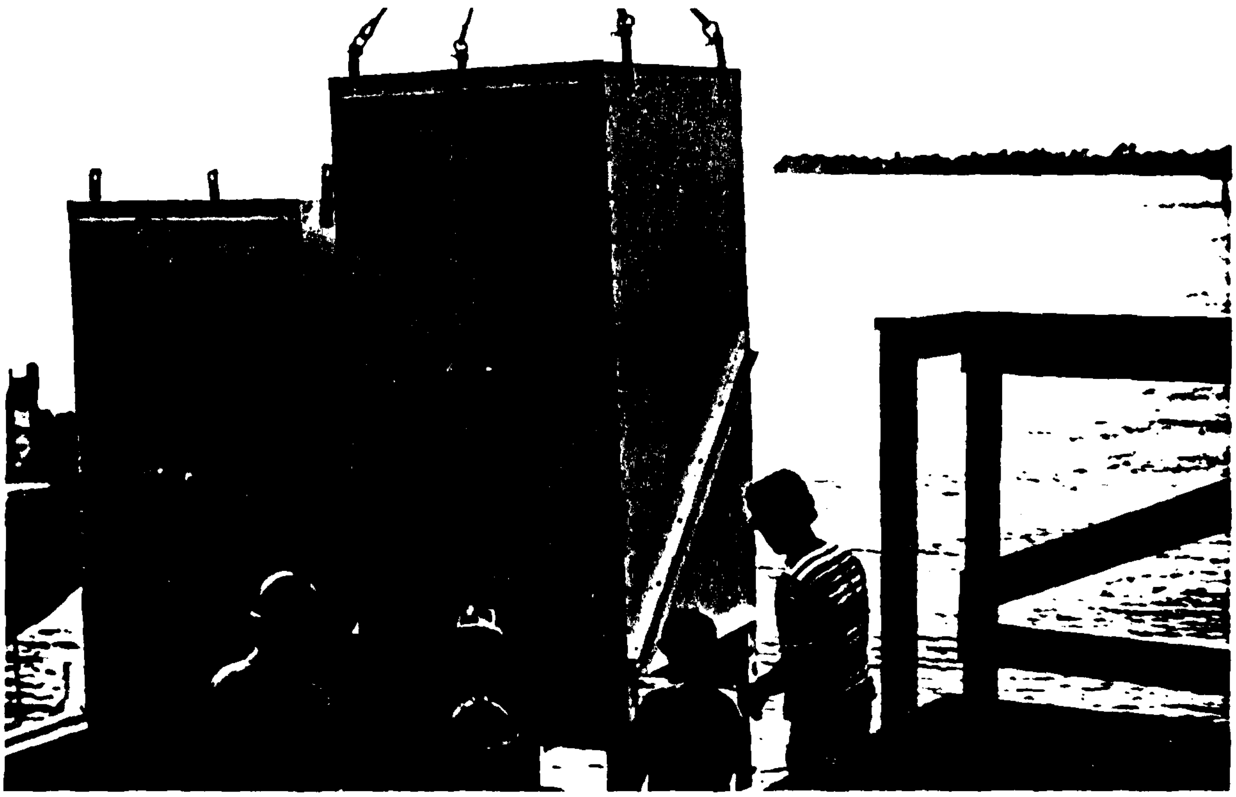
The bottom directly below the three boxes was littered with instrumentation cables. Without tracing each back to its source in the magnetometer array, it could not be determined which cables were active. The area was cleared for jetting in the lower framework legs simply by displacing all the cables to immediately outside the boundaries of the framework.

The soft mud was easily displaced using a fire hose with suicide nozzle as the jet. On the third stilling well, the leg members supplied were shortened by 4 feet each to reduce the embedment length to 3 feet.



JUNCTION BOX BEING LIFTED INTO PLACE

FIGURE 7–13



LOWERING THE SECOND BOX ONTO SUPPORT CHANNELS

FIGURE 7–14

The 12-inch channel sections, into which the cable clamps would fasten, were all bolted in place. One channel section, which was not designed to accommodate clamp assemblies, could not be placed due to interference with a buried piling. The CHESNAVFACENGCOM representative decided further effort to set this component was unnecessary as it was not critical to the stability of the stilling well. The framework installation was completed on 21 January. The stilling well panels would be installed after the cables were in position.

CABLE ROUTING TO THE JUNCTION BOXES

Routing of the Z-loop cables into the junction boxes began on 22 January. Because it was neap tide, it was unnecessary to remove the cross braces to pass the cable through the framework -- it could readily be passed under the brace without interfence. Tide charts indicated this low water level would continue for seven days.

The cables were routed into the boxes as outlined in Section 4.0. To prevent mix-up, each cable end was passed through individually and its identification tag replaced inside the box.

The terminal strips had been removed from the boxes for modification prior to pulling the cables into the boxes. The center bussing strip was still in place. As each cable end was passed into the box, it was cut to size based on the position it would occupy when the strips were reinstalled.

The 105 cables were evenly divided among the three boxes. With 35 cables per box, the parallel loops within each box were to receive 17 and 18 turns respectively.

After the first ten cable end pairs were complete, the electricians were instructed to concentrate their efforts on assisting the divers with the rerouting process. Cutting and lugging of the cable ends could be performed more efficiently en masse rather than individually as each cable end was secured. The ends of each cable were heavily taped to prevent water intrusion.

On 26 January 1983, the original schedule was scrubbed. It was apparent that insufficient time remained to fix adequately the existing electrical system. The remaining cables would be rerouted but no further cables were cut or lugged. Rerouting was completed on 26 January. All but the first 10 cable pairs remained unlugged. Figure 7-15 illustrates the routed but unterminated cables.

INTERIOR OF BOX BEFORE INSTALLATION
OF REDESIGNED TERMINAL STRIPS

FIGURE 7-15

PARTIALLY ASSEMBLED STILLING WELL PANELS;
CABLE CLAMPS AND KJELLAM TYPE GRIPS ALSO VISIBLE

FIGURE 7-16

During the cable re-rating, one faulty cable was discovered. This cable, after being carefully retested several times with two meggers, was not incorporated in the system. The accessible length was cut off and the remaining cable was discarded in place. One cable, which had a low megger reading when layed, had lost additional insulation resistance, but was still adequate. Two cables which showed no apparent trouble when layed, had dropped appreciably in resistance, but also remained usable. These three cables were installed in the boxes, but would be monitored to determine their future usefulness.

STILLING WELL PANEL ASSEMBLY

Installation of the stilling well panel assembly began on 26 January, starting with the underwater panels. The divers experienced some difficulty aligning the holes in the panels with those in the framework. The number of connectors, and their small size, made this installation difficult in the zero visibility water. The divers recommended the use of slotted holes to ease the alignment problem in future designs. The lowermost panels on the east and west facing sides of the stilling wells could not be installed because the 208 cable ends entering from the east side formed a stack somewhat above the mud line as they ran along the bottom. The underwater panel assembly was completed on 29 January 1983.

The topside panels were installed by PWC sheetmetal workers from scaffolding installed by PWC riggers. Figure 7-16 shows the partially assembled panels, as well as the cables as they hang within the stilling well. The uppermost east and west panels (not yet installed in Figure 7-16) were modified by cutting away a portion of the top flange to accommodate braces added to the design by PWC engineers.

Panel installation was completed on 2 February 1983. The site was cleaned and secured on 4 February pending redesign of the terminal strip assemblies. The existing hardware was shipped to the contractor's facilities for examination and determination of the best course of action.

JUNCTION BOX INSPECTION AND REFIT

Results of the terminal strip and bus bar inspection conducted by the PWC Electrical Section were published in an undated memorandum received by the Magnetic Silencing Facility on 1 February 1983 which stated the equipment did

not meet specifications of the 1981 National Electrical Code or Underwriter's Laboratories. This conclusion corroborated the doubts of the deperming engineer and facility electrician about the electrical adequacy of the switching matrix.

After inspection in his shop, the contractor determined that the existing system would require replacement rather than modification. He also confirmed that the doors did not meet code requirements for thickness, rigidity, or watertight integrity. Both components were redesigned to meet code specifications. The terminal strip redesign was approved by CHESNAVFACENGCOM on 25 March 1983 and the replacement doors were approved on 19 April 1983.

RESPONSIBILITIES. Installation of the redesigned strip and door assemblies became the responsibility of the design contractor and the fabrication subcontractor. They also agreed to paint the interiors, repaint the exteriors, and assure complete watertight integrity of the enclosures. As had originally been planned, PWC electricians would terminate and connect all cables, and PWC carpenters would fabricate a cover for the power cable trough.

The CHESNAVFACENGCOM technical representative, and the contractor and subcontractor representatives, arrived on site on 16 May 1983 to implement these changes.

BOX PREPARATION. Interior painting required careful masking of the 208 cable ends routed into the boxes, as shown in Figure 7-17. All inside joints were sealed with an approved silicone caulk. All surfaces were washed with an acid primer, then coated with MIL-P-24441/3 epoxy paint. Interior painting was completed on 19 May. The existing doors and frames were removed on 20 May and the redesigned components were delivered that afternoon.

STRIP INSTALLATION. The terminal strips were installed on 22-24 May. To facilitate cable connection, two of the four strips comprising each assembly were not bolted into place -- these would be installed, as needed, after fastening half the cables in each enclosure.

Z-LOOP CABLE CONNECTION. Electricians from PWC arrived on 25 May. Each cable end was cut to size, meggered, lugged, sealed with heat shrink tubing over the lug sleeve-cable insulation interface, and bolted into place. Figure 7-18 shows a detail of the cable connection. The cable connection

MASKING CABLES
FOR INTERIOR PAINTING

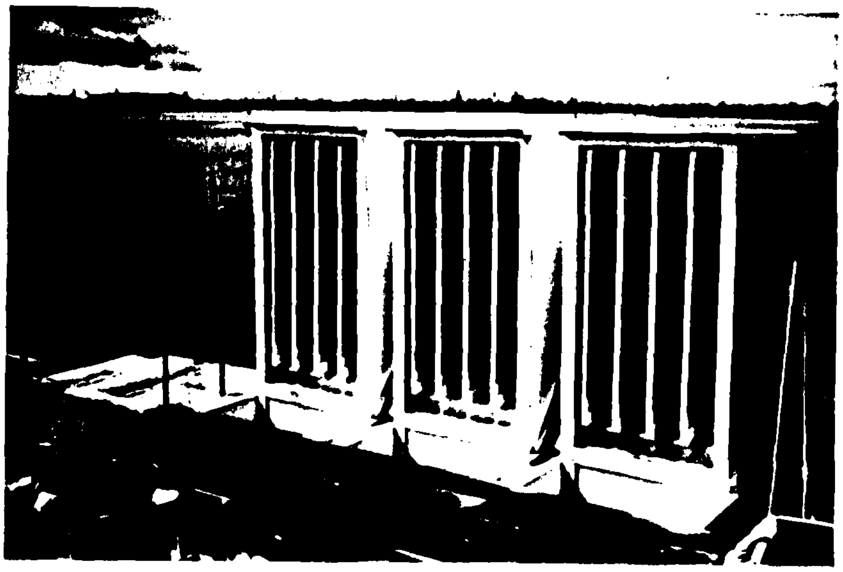
FIGURE 7-17

TERMINAL STRIP SHOWING
CABLE CONNECTION SCHEME

FIGURE 7-18

BOXES PRIOR TO ATTACHING
NEW DOOR ASSEMBLIES

FIGURE 7-19



log containing the make-up of each parallel circuit and the insulation resistance of each cable when connected is included in this report as Appendix B. Z-loop cable connection work was completed on 27 May 1983. In Figure 7-19, all Z-loop turns have been terminated and installed.

DOOR ASSEMBLY INSTALLATION. The frames and doors were installed on 28 and 29 May. A final top coat was applied to them and the required "High Voltage" decals were applied to the insides and outsides of each of the six doors. This completed the contractor's obligations. The CHESNAVFACENGCOM representative remained to complete the installation.

POWER CABLE CONNECTION. The twenty-four power feed cables were installed from 31 May to 3 June. This 500 MCM, 37 strand cable is very stiff and difficult to handle. The cables had been rerouted from the existing junction boxes into a temporary hook-up with 30 of the new Z-loop cables as an interim measure. They were now routed through the cable trough as originally planned.

PWC carpenters constructed a new cable crib to span the power cables access cut in the south quay wall. Two lengths of Superstrut® channel were bolted into the timber framework of the crib. The porcelain cable brackets from the existing Z-loop power feed routing crib were reused. Figure 7-20 shows the new cable crib. To complete the installation, the cable trough was covered using lengths of 4 x 12 creosoted timbers. The trough cover is partially visible in Figure 7-21. The completed installation is shown in Figure 7-22.

Z-LOOP TESTING

Each of the six parallel circuits was tested on 7 June 1983 to determine both the continuity and consistency of the circuits. The power cables were isolated from each circuit and a portable power source connected. The magnetic field generated by the application of 5 amps at 4 VDC through each circuit was measured and compared with the theoretical field generated by one cable multiplied by the number of loops in each circuit. (As detailed in Appendix B, 4 of the circuits contain 17 cable loops, the remaining two have 18 loops.)

As a result of this procedure, circuit 5 was found to contain 2 cables whose ends were reversed. Individual testing of each cable in the circuit readily determined the errant hook-ups. When properly connected,

POWER FEED CABLE CRIB

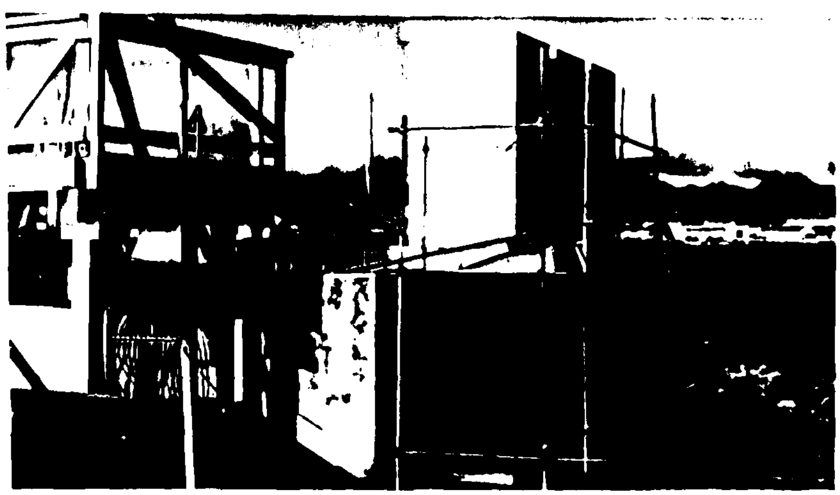
FIGURE 7-20

JUNCTION BOXES AT COMPLETION OF PROJECT

FIGURE 7-21

JUNCTION BOXES AND STILLING WELLS

FIGURE 7-22



the resulting field again compared favorably with theoretical values.

A full power load test was not performed because the resulting magnetic field would be well beyond the range of the instrument array, and hence have been of no value in determining the continuity or consistency of the Z-loop.

The Pearl Harbor Magnetic Silencing Facility CASREP was cancelled by message on 9 June 1983 returning the station to operational status.

8.0 PROJECT COST SUMMARY

The Pearl Harbor Z-Loop Upgrade Project was completed within its revised budget, which included the additional costs incurred to complete the refit. Note that all figures in the following summary are unaudited and are to be used for reference only.

PROJECT COST -- DESIGN AND INSTALLATION

(Deperming Cable Provided by NAVSEA)

CHESNAVFACENGCOM		$112,015
Technical advisor; project supervision; financial management; labor, travel, and per diem		
Contractor Support		$300,640
1. VSE Corp.		
a. design and fabrication of junction boxes; field support	$172,212	
b. redesign, fabrication and installation of terminal strips and doors	$ 60,784	
2. Tracor Marine, Inc.		
OCEI materials and logistics support	$ 58,619	
3. Robert Taggart Incorporated		
Preparation of completion report	$ 9,025	
UCT-TWO		$ 58,831
Installation of Z-loop cables; instrumentation survey and replacement; materials; travel and per diem		
Public Works Center		$ 79,041
Pile driving, counterweight and saw-cutting contracts; base system preparation; junction box installation; cable termination		
Naval Station Pearl Harbor		$ 37,000
LCM and operator; crane operator; miscellaneous expenses and procurements		
	Total Cost	$587,527

9.0 AS-BUILT DRAWINGS

The as-built configuration of the Z-loop cable path is shown in Figure 3-2. The guide piles were set to provide a rectangular path, 510-feet long by 80-feet wide, positioned with respect to the existing magnetometer array as follows:

The loop is centered about instrument 15H, extending 40 feet east and west of this point, and 255 feet to the north and south. These north and south edges pass midway between instrument columns 23 and 24, and 6 and 7 respectively. The east and west sides pass outside rows F and J, running parallel at a spacing of 80 feet. The detailed description of the location of all existing instrumentation is on file at Magnetic Silencing Facility, Code 37, Naval Station Pearl Harbor, Pearl Harbor, HI 96860.

The as-built drawings of the junction box system are listed below. The package is on file at CHESNAVFACENGCOM, Code FPO-1, Washington Navy Yard, Washington, D. C. 20374.

Title	NAVFAC Dwg. No.
Junction Box Switching Matrix Assembly, Sheet 1 of 10	3026328
Junction Box Assembly, Sheet 2 of 10	"
Junction Box Matrix, Sheet 3 of 10	"
Junction Box Assembly, Sheet 4 of 10	"
Junction Box Details, Sheet 5 of 10	"
Junction Box Assembly, Sheet 6 of 10	"
Junction Box Assembly, Sheet 7 of 10	"
Junction Box Assembly, Sheet 8 of 10	"
Junction Box Assembly, Sheet 9 of 10	"
Junction Box Assembly, Sheet 10 of 10	"
Junction Box/Stilling Well Assembly, Sheet 1 of 5	3026329
Junction Box/Stilling Well Assembly, Sheet 2 of 5	"
Junction Box/Stilling Well Assembly, Sheet 3 of 5	"
Junction Box/Stilling Well Assembly, Sheet 4 of 5	"
Junction Box/Stilling Well Assembly, Sheet 5 of 5	"

Title	NAVFAC Dwg. No.
Stilling Well Components, Sheet 1 of 4	3026330
Stilling Well Components, Sheet 2 of 4	"
Stilling Well Components, Sheet 3 of 4	"
Stilling Well Components, Sheet 4 of 4	"
Terminal Assembly Details, Sheet 1 of 4	3026331
Terminal Assembly Details, Sheet 2 of 4	"
Terminal Assembly Details, Sheet 3 of 4	"
Terminal Assembly Details, Sheet 4 of 4	"
Door Assembly Details, Sheet 1 of 7	3026332
Door Assembly Details, Sheet 2 of 7	"
Door Assembly Details, Sheet 3 of 7	"
Door Assembly Details (Frame), Sheet 4 of 7	"
Door Assembly Z-Loop Junction Box, Sheet 5 of 7	"
Door Assembly Z-Loop Junction Box, Sheet 6 of 7	"
Door Assembly (Hinge Redesign), Sheet 7 of 7	"
Terminal Assembly Z-Loop Junction Box, Sheet 1 of 5	3026333
Terminal Assembly Z-Loop Junction Box, Sheet 2 of 5	"
Terminal Assembly Z-Loop Junction Box, Sheet 3 of 5	"
Terminal Assembly Z-Loop Junction Box, Sheet 4 of 5	"
Terminal Assembly Z-Loop Junction Box, Sheet 5 of 5	"

10.0 LESSONS LEARNED AND RECOMMENDATIONS

The Pearl Harbor Z-loop upgrade was completed in June 1983, four months after the planned completion date of February 1983. This delay necessitated rescheduling one planned operation, but adequate cancellation lead time minimized the impact on the fleet. Because the cables were routed into the junction boxes in January, as planned, deperming facility personnel were able to rig a temporary connection in order to complete another scheduled operational commitment.

The problems encountered during project execution are discussed below. Lessons learned during the installation and recommendations for future consideration are included.

INSTALLATION OF THE Z-LOOP

The cable-laying portion of the project was completed on schedule. Some difficulties were encountered, however, particularly during the early stages of the installation.

The rock outcropping and steep slope in the Z-loop path were not documented during preliminary planning. As a result, turning templates were fabricated, deployed, and retrieved without utilization. This outcropping also forced the only deviation from the intended rectangular cable path. Time constraints and the presence of existing instrumentation cables precluded removal of the outcropping; such a measure should be considered during any future Z-loop upgrade.

The planned catenary monitoring technique was abandoned very early in the evolution in favor of the float balloon concept. This change facilitated slack removal during successful turns and eased cable retrieval when an insulation fault was discovered.

Nine cables were retrieved due to insulation faults discovered while laying the cable. Continuous megger monitoring allowed retrieval before completing the turn, saving considerable time. Concepts for testing the cable prior to handling were considered, but no effective, adequate method was developed. Insulation testing by the manufacturers prior to shipping reportedly conformed to industry standards. However, in an application where a single pinhole fault midway in a reel of cable results in loss of

the entire reel, more stringent standards are necessary. In addition, some timber reels had nails and rough/sharp spots on the inner surface of the flanges. These could have caused the insulation faults. Higher quality timber reels may be required to protect the insulation.

Procurement of the deperming cable in 1500 foot continuous lengths proved a prudent decision. Although the actual length of each turn, from the termination point at the junction boxes, was approximately 1300 feet, the extra length was useful in several ways. In four cases an insulation fault was found within the first 200 feet of cable while paying out cable onto the south quay prior to beginning the run. The fault was cut off still leaving adequate length to complete the turn. In two cases, the unused length remaining after completing the loop was spliced onto short reels, thus increasing the total number of turns laid. Finally, excess cable cut from the completed turns could be utilized in ship wrapping operations.

JUNCTION BOX DESIGN AND INSTALLATION

The delayed completion of the project is attributable to the lack of adequate clearances between parts in the original electrical switching matrices. These discrepancies were a result of misinterpretation of the code requirements for this unique application. The statement of work issued to the contractor specified that the design of the electrical distribution system be "in accordance with best industry standards." The system, which was designed according to IEEE standards by the contractor, did not meet National Electric Code requirements, which, in the final analysis, were judged to take precedence. The existing equipment could not be modified to meet this code. The redesigned terminal strips were revived by CHESNAV-FACENGCOM to assure compliance with all applicable codes.

The enclosure door design was called out in the shop drawings as "doors similar to ..." a previously fabricated assembly and was not analyzed by CHESNAVFACENGCOM for structural stiffness.

After fabrication, the boxes were accepted and released for shipment by the contractor. The contractor's experience and track record should have prevented the silver plating and watertight integrity discrepancies found in the final product.

It is recommended that monitoring of a contractors' activities be continued through all phases of the design and fabrication process. This should not be construed as a need for duplication of effort, but as a form of quality control to assure all task requirements are met. The selected A&E should have a prior record of providing code-acceptable designs; key contractor personnel should have a demonstrated knowledge as to which codes are applicable.

During the installation plan review process, PWC engineers recommended considerable alteration to the box support structure, as has been described. Although analysis showed the support channels and the proposed counterweight connection to be adequate, the PWC-proposed additions were approved and incorporated into the design. Lenghthening and increasing the section modulus of the support channels by replacing the original components during fabrication would also have resulted in added degree of safety. The acceleration of the installation schedule influenced the decision to supplement the original design rather than delay shipment by modifying the approved and already fabricated supports. Modification at the original fabrication location would have resulted in fewer installation problems and in reduced final cost.

STILLING-WELL INSTALLATION

The stilling-well panels posed the only assembly problem during the installation. Each panel was secured with ten 1/4-inch bolt assemblies fastened through 5/16-inch holes. Making these connections was complicated by water with near-zero visibility. It is recommended that, wherever applicable in the future, diagonally oriented slotted holes be specified to ease underwater assembly tasks. In addition, as no load is applied directly to the panels, fewer connections are necessary to join the parts. Underwater assembly should be made as simple as an adequate final installation will permit.

11.0 ACKNOWLEDGMENTS

In August and September 1982, members of various naval commands deployed to U. S. Naval Station, Pearl Harbor, Hawaii, in accordance with Operation Order UCT-TWO 11-82 to upgrade the Magnetic Silencing Facility Z-loop.

Assisting in this operation from the Ocean Engineering and Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (CHESNAVFACENGCOM), as Engineer-in-Charge was Mr. David Raecke, who served as customer liaison, authorized to approve/disapprove technical matters, and make final acceptance of the work performed. Mr. Raecke was accompanied by Ms. Arlene Dodson, and Mr. Bruce Schuckman, who provided construction engineering field support.

The installation of the Z-loop was performed by members of Underwater Construction Team Two (UCT-TWO) under the direction of POIC Senior Chief Bradshaw, supported by MSF personnel under the command of CWO4 Bickel.

An LCM with operator, and a YC barge were provided by the Naval Station Pearl Harbor. The NAVSTA PEARL also provided additional labor support as required.

A mobile crane/cherry picker with operator and other construction equipment were provided by Public Works Center Pearl Harbor (PWC PEARL).

Administrative, berthing, and logistics support were provided by the Magnetic Silencing Facility, Naval Station, Pearl Harbor.

Junction box installation, cable routing, and cable connections were performed by a team comprising divers from Mobile Diving and Salvage Unit One (MSDU-ONE), Detachment 220, under the direction of Senior Chief Penn and skilled tradesmen from PWC PEARL.

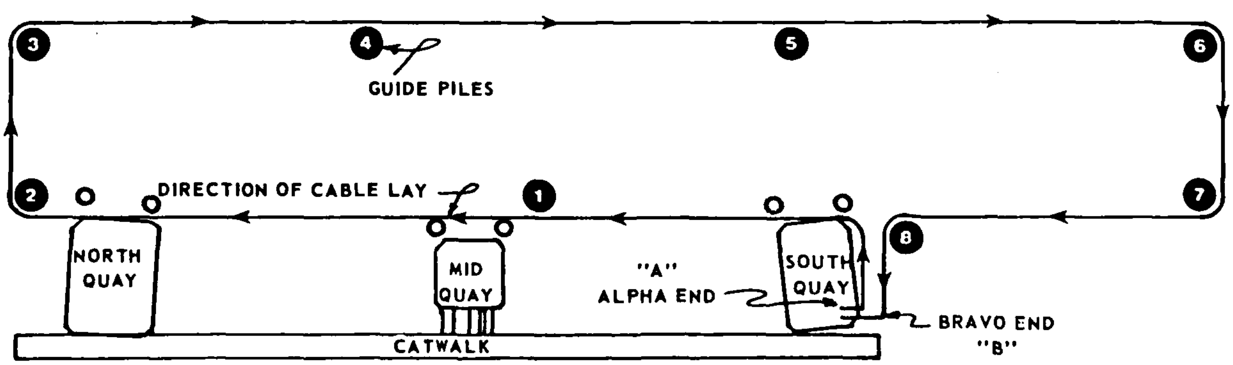
APPENDIX A

Z-LOOP CABLE INSTALLATION LOG

This appendix provides a complete log of all of the Pearl Harbor Z-loop cables that were laid, including those that were later removed. Identification of the data items contained within the log is provided in the table below and Figure A-1 shows the pattern of cable laying that was utilized for information in interpretation of the logged data. The Alpha end of the cable was

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	IDENTIFICATION OF DATA IN CABLE INSTALLATION LOG SHEETS
6A					End of cable 6 attached to south quay at start of cable lay. See Figure A-1.
6B					Bitter end of cable loop 6 attached to south quay at completion of lay.
	15				Fifteenth cable-laying operation.
~~15A~~ ~~15B~~	~~15~~				Diagonal line indicates cancellation of lay and removal of cable.
		9/18 0900 1015			Month and day, 1982, when cable was laid. Hour of day (HST) at start of cable lay. Hour of day (HST) at completion of loop.
			54184 3955# 1600'		Number or make of cable reel. Gross weight of cable and reel. Length of cable marked on reel.
				200	Megger reading in megohms at end of loop.

attached to the south quay and the LCM 6 then backed to the north reeling off cable under tension. It made the circuit around the guide piles to pile #8, where the Bravo end was taken off and secured to the south quay.



PATTERN OF CABLE LAYING AROUND PILES

FIGURE A-1

END DLS	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
1A 1B	1	9/18 0900 1015	54184 3955# 1600'	200	First evolution. Template not used due to slope at piles #7 and #8. Bitter end snags on jackstand needs to be cut away 4 times. End also contacts stand causing low megger readings cable brake and angle of entry method used.
~~1A~~ ~~1B~~	~~1~~	9/20 0930 1030			Divers inspected cable 1. Report excessive tension in loop, particularly at pile turns. East side not in line with the intended configuration. Cable approx 6 inches below mud line. Cable recovered by re-reeling.
2A	2	9/20 1152 ----	92339 3920# 1600'	GR	Same technique; smooth until 300 feet payed out, where megger dropped to 0. Cable marked for inspection.
~~2A~~	~~2~~	9/20 1220 1300			Cable retrieved. Inspection at marked point shows two indentations, likely manufacturer's defects. Cable remaining on reel insufficient to complete loop.
3A 3B	3	9/20 1450 1520	92328 3130# 1510'	∞	First use of float balloons (250# lift cap); 35 balloons attached to cable beginning at NE pile. Divers remove floats 1520/1640. Slack pulled 9/22; 10' 3" from "A"; 0 from "B" end
4A 4B 5A 5B	4 5	9/21 0800 0940 9/21 0800 0940	54037 4060# 1600' 53359 3650# 1558'	∞ ∞	First multiple cable lay. Difficult keeping equal tension/slack sequence on separate reels. Cables floated together on balloons; when cable crossed bow of 18 foot boat (used to tie balloons and control slack), cable snagged control box and pulled it out of deck. Return next to single lay. Slack pulled 9/23; 4B-17' 10", 5B-11' 7", 4,5A-0'.
6A 6B	6	9/21 1220 1338	Pirelli 1600'	∞	Single lay. Non-sequential popping of floats increases slack with possible result in loops and nonlinear runs of cable. Slack pulled 9/23: 6A-5', 6B-40'. Laying operation much smoother than previously.
7A 7B	7	9/21 1300 1354	54030 3605# 1565'	∞	Single lay. Non-synchronous release of floats increases slack. Future runs method will be modified to release floats one at a time in order of attachment, with sufficient time to drop cable to bottom. Slack pulled 9/23 is over 30 feet.
		9/22			Diver check of installed cables. Report slack, loops, and irregularities which are walked out. (Slack pulled recorded above)

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
		9/23			Three cables meggered as faulted after this operation. Chafe in cable 7 fitted with heat shrink.
8A ~~8A~~	8 ~~8~~	9/24 0826 0840	54014 3605# 1500'	GR	Fault found at 100 feet. Cable cut and marked at fault.
9A 9B	8	9/24 1020 1105	82691 3920# 1600'	200	Single lay. Floats beginning at center quay. Balloons popped in sequence and cable dropped to bottom. Final slack pulled at south quay. Result is good, tight, regular lay.
8A 8B	9	9/24 1235 1332	54014 3605# 1400'	200	Re-lay cable 8. Execution same as cable 9. Shortened reel approx 50 feet cable back to quay.
10A 10B	10	9/24 1542 1640	82606 3785# 1600'	200	Single lay; laid without incident.
3A,B 4A,B 5A,B		9/25			Three cables faulted (megger to zero), possibly during slack pull and inspection. Cables cut away and removed from loop.
11A 11B	11	9/27 0820 0906	54008 3825# 1600'	200	Visible gash in insulation spotted at 33 feet and cut from reel. Single lay. Slack at "B" end pulled by come-along and manpower, approximately 20 feet.
12A 12B	12	9/27 0945 1015	54005 3955# 1600'	∞	Single lay. Very smooth loop run. Approx 30 feet slack pulled in by manpower on quay. Bitter end marked to check unused extra cable.
13A 13B	13	9/27 1120 1225	87155 3740# 1600'	20	Single lay. Megger showing erratic readings, e.g., 5 MΩ at pile #6, 8 MΩ at pile #7, 20 MΩ when bitter end on quay. Next day reading 14 MΩ. End marked for excess.
14A 14B	14	9/27 1330 1428	Tara 3710# 1500'	100	Single lay. First Tara reel. Reel held up to strain. No incidents.
15A 15B	15	9/27 1545 1615	92834 2795# 1575'	GR	Single lay. Megger dropped to zero approx 75 feet beyond pile #6. Lay continued due to possible ground of bitter end against reel. Eighteen footer underran cable at fault point. Megger went up to 6 MΩ. Touch inspection found leakage at several points in this area.
~~15A~~ ~~15B~~	~~15~~	9/27 1640 1715			Cable retrieved due to faults.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
16A 16B	16	9/28 0825 0918	92478 3840# 1600'	∞	Single lay. Laid without incident. Float begin at south quay. Manpower alone to bring in slack.
17A 17B	17	9/28 1008 1034	92848 4000# 1600'	∞	Cable laid without incident.
18A 18B	18	9/28 1158 1234	54050 3785# 1600'	∞	Cable laid without incident despite 20 to 30 kt winds.
19A 19B	19	9/28 1305 1340	92889 3870# 1600'	100	Single lay. Stiff breeze made LCM maneuvering difficult. Zodiac used at pile #2 to push stern of LCM on line. More slack in loop than has become usual due to wind and float slippage causing larger catenary.
20A 20B	20	9/29 0827 0900	53747 3725# 1600'	200	Cable laid without incident.
21A	21	9/29 0930 ----	54009 3990# 1600'	GR	Megger dropped below 10 KΩ just past pile #3. Returned to 20 MΩ between piles #2 and #3.
~~21A~~	~~21~~	9/29 1002			Cable retrieved due to fault.
22A 22B	22	9/29 1015 1045	53548 3650# 1600'	∞	Cable laid without incident.
23A 23B	23	9/29 1145 1212	Tara 3630# 1500'	200	Second Tara cable laid without incident.
24A 24B	24	9/29 1258 1327	92321 3680# 1600'	∞	Spliced at 100 foot (factory) but no discontinuity. Three balloons bunched at pile.
25A 25B	25	9/29 1355 1422	52197 3855# 1600'	200	Cable laid without incident despite maneuvering difficulty for LCM
26A 26B	26	9/29 1451 1515	54183 3810# 1500'	∞	Cable laid without incident.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
27A 27B	27	9/30 0807 0835	Tara 3620# 1500'	200	Tara 3 cable laid without incident.
28A 28B	28	9/30 0842 0920	54070 3830# 1600'	∞	Transmission of LCM malfunctioned at pile #3. Repaired on spot easily. No other incidents
29A 29B	29	9/30 0930 1000	92804 3830# 1588'	∞	Cable laid without incident.
30A	30	9/30 1005	53600 3630#	GR	Megger dropped to zero at center quay.
~~30A~~	~~30~~	1040	1530'		Cable retrieved due to fault(s).
31A 31B	31	9/30 1123 1150	54103 3960# 1600'	∞	Cable laid without incident.
32A 32B	32	9/30 1250 1320	54045 3860# 1600'	∞	Cable laid without incident.
33A 33B	33	9/30 1350 1420	53402 4040# 1600'	∞	Cable laid without incident.
34A 34B	34	9/30 1435 1515	54072 3750# 1600'	∞	Cable laid without incident.
35A 35B	35	10/1 0825 0852	53688 3800# 1600'	200	Approximately 60 feet slack pulled from "B" end. No incidents.
36A	36	10/1 0915	54071 3690# 1600'	GR	Megger dropped below 1 MΩ 50 to 100 feet beyond pile #2.
~~36A~~	~~36~~	10/1 0935			Cable retrieved due to fault.
37A	37	10/1 0942	93250 3890# 1600'	30	Immediate low megger at south quay.
~~37A~~	~~37~~	0955			Cable retrieved due to low megger reading

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
38A 38B	38	10/1 1037 1100	54106 3750# 1600'	∞	Cable laid without incident despite 25 kt winds.
39A 39B	39	10/1 1123 1150	54032 3870# 1600'	∞	Heat shrink tube applied near "B" end to seal partial cut thro gh insulation
40A 40B	40	10/1 1220 1250	54063 3725# 1585'	∞	Intense rain squall began at pile #4. Lost megger between piles #5 and #6 due to wetness. Cable tested ok.
41A 41B	41	10/1 1330 1355	98294 3750# 1600'	180	Cable laid without incident.
42A 42B	42	10/4 0818 0843	54054 3550# 1550'	200	Cable laid without incident.
43A	43	10/4 0925	56411 3750# 1600'	GR	Megger dropped to 10 KΩ between piles #4 and #5. Returned t 200 MΩ at pile #4 during re-reeling.
~~43A~~	~~43~~	0956			Cable retrieved due to fault.
44A 44B	44	10/4 1015 1043	92359 3855# 1600'	∞	Cable laid without incident.
45A 45B	45	10/4 1130 1158	52027 3895# 1600'	∞	Cable laid without incident.
46A 46B	46	10/4 1228 1255	54011 3735# 1600'	50	Initial megger of ∞ dropped to 50 MΩ at end of loop. No incidents.
47A 47B	47	10/4 1335 1403	54117 3920# 1600'	200	Transmission trouble on LCM between piles #4 and #5 quickly resolved. No other incidents.
48A 48B	48	10/4 1440 1502	92344 3860# 1600'	∞	Cable laid without incident.
49A 49B	49	10/5 0813 0841	54044 3815# 1600'	∞	Cable laid without incident. Sixty feet (approx) slack pulled from "B" end.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
50A 50B	50	10/5 0923 0949	87016 3780# 1590'	∞	Divers report loop is very tight around piles; slack given
51A 51B	51	10/5 1030 1055	87087 3750# 1600'	100	Cable laid without incident.
52A 52B	52	10/5 1115 1140	54041 3920# 1600'	∞	Cable laid without incident.
53A 53B	53	10/5 1247 1316	54096 3655# 1549'	∞	LCM had difficulty making turn at pile #7. No excess slack or other incident.
54A 54B	54	10/5 1345 1410	92250 3920# 1600'	∞	Cable laid without incident.
55A 55B	55	10/5 1438 1507	92251 3850# 1600'	∞	Cable laid without incident.
56A 56B	56	10/6 1253 1320	92295 3480# 1500'	∞	Camel broke loose at south quay and drifted into cable path. Camel secured without harm to cable.
57A 57B	57	10/6 1340 1402	54056 3655# 1550'	∞	Cable laid without incident despite maneuvering difficulty at turns.
58A 58B	58	10/6 1425 1450	54038 3845# 1600'	∞	Wide turn at pile #7. Cable laid without incident.
59A 59B	59	10/6 1525 1553	92567 4000# 1600'	200	Bitter end submerged at end of lay. Ten feet promptly removed to prevent further intrusion.
60A 60B	60	10/7 0727 0750	55408 3990# 1600'	200	Cable laid without incident.
61A 61B	61	10/7 0850 0920	52194 3920# 1600'	100	Bitter end grounded against reel at pile #2; condition repaired. Cable ok.
62A 62B	62	10/7 0943 1041	92835 3930# 1600'	200	Megger dropped to 10 KΩ at pile #1. Suspected pinhole fault removed by cutting 130 feet from "A" end. At

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
					pile #3, LCM caught instrument float line in screw. Swimmers freed line. Cable undamaged.
63A 63B	63	10/7 1136 1206	87013 3790# 1600'	100	Megger read erratically initially 10 KΩ to 2 MΩ. Fault spotted at 185 ft, and cut away. Bitter end grounding on reel. Cable ok.
64A 64B	64	10/7 1250 1313	93290 3695# 1590'	∞	Cable laid without incident.
65A 65B	65	10/7 1343 1408	53408 3905# 1600'	∞	Cable laid without incident.
66A 66B	66	10/7 1440 1507	52134 3920# 1600'	∞	Cable laid without incident.
67A 67B	67	10/9 0735 0806	Tara Re-reel	100	Tara 4 cable laid without incident.
68A 68B	68	10/9 0820 0847	Tara 3810# 1600'	100	Tara 5 cable laid without incident.
69A 69B	69	10/9 0925 0950	Tara 3640# 1500'	100	Tara 6 cable laid without incident.
70A 70B	70	10/9 1026 1053	Tara 3795# 1570'	80	Tara 7 cable end possibly grounding. against reel. Final megger reading shown.
71A 71B	71	10/9 1145 1218	87864 3810# 1600'	∞	Two reel numbers attached. Second may be 93689 (illegible). With LCM at pile #6, divers found cable not tied off. Zodiac used to return slack to "A" end.
72A 72B	72	10/9 1250 1323	88183 3810# 1600'	∞	Cable laid without incident despite high winds.
73A 73B	73	10/9 1340 1400	93622 4015# 1600'	200	Cable laid without incident.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
74A 74B	74	10/11 0816 0844	Tara 4010#	100	Rain caused intermediate megger of 30 MΩ. No other difficulties. Tara 8.
75A 75B	75	10/11 0910 0933	Tara 3760# 1500'	150	Cable laid without incident. Tara 9.
76A 76B	76	10/11 0955 1015	Tara Re- reel	100	Cable laid without incident. Tara 10.
77A 77B	77	10/11 1036 1055	87179 3800# 1550'	200	Cable laid without incident.
78A 78B	78	10/11 1142 1200	Tara 4020# 1650'	100	Cable laid without incident. Tara 11.
79A 79B	79	10/11 1220 1241	Tara 3775# 1500'	100	Cable laid without incident. Tara 12.
80A 80B	80	10/11 1305 1328	Tara 3610# 1500'	150	Cable laid without incident. Tara 13.
81A 81B	81	10/11 1341 1401	Tara 3605# 1500'	100	Cable laid without incident. Tara 14.
82A 82B	82	10/12 0727 0745	Tara 3730# 1500'	100	Cable laid without incident. Tara 15.
83A 83B	83	10/12 0803 0820	Tara 3735# 1530'	50	Bubble in insulation at 175 feet from "A" end cut from cable. No incidents. Tara 16.
84A 84B	84	10/12 0840 0857	Tara 3700# 1500'	200	Gash in insulation at 15 feet from "A" end cut from cable. No incidents. Tara 17.
85A 85B	85	10/12 0930 0947	Tara 3450# 1500'	200	Cut in insulation at 180 feet from "A" end cut from cable. No incidents. Tara 18.
86A	86	10/12 1040	Tara 3750#	GR	Megger reading 30 MΩ at pile #2, less than 1 MΩ at pile #5. Tara 19.
~~86A~~	~~86~~	1110	1500'		Cable retrieved due to fault.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
87A 87B	87	10/12 1115 1140	Tara 3710# 1500'	100	Cable laid without incident. Tara 20.
88A	88	10/12 1154	Tara 3650#	GR	Megger reading dropped below 1 MΩ at pile #2. Tara 21.
~~88A~~	~~88~~	1213	1510'		Cable retrieved due to fault.
89A 89B	89	10/12 1310 1328	Tara Re- reel	100	Cable laid without incident. Tara 22.
90A 90B	90	10/12 1347 1405	Tara Re- reel	150	Cable laid without incident. Tara 23.
91A 91B	91	10/12 1426 1444	Tara 3720# 1500'	150	Cable laid without incident. Tara 24.
92A 92B	92	10/12 1506 1522	Tara 3645# 1500'	100	Cable laid without incident. Tara 25.
93A 93B	93	10/13 0737 0754	Tara Re- reel	100	Cable laid without incident. Tara 26.
94A 94B	94	10/13 0812 0828	Tara 3665# 1500'	200	Cable laid without incident. Tara 27.
95A 95B	95	10/13 0840 0900	Tara 3930# 1650'	100	Cable laid without incident. Tara 28.
96A	96	10/13 0915	Tara Re- reel	GR	Megger reading dropped to zero at pile #6. Returned to 100 MΩ between pile #5 and pile #6. Tara 29.
~~96A~~	~~96~~	0955			Cable retrieved due to fault.
97A 97B	97	10/13 1034 1100	54010 3940# 1600'	∞	Four balloons adrift between piles #4 and #6; extra slack pulled ashore. No incidents affecting cable.
98A 98B	98	10/13 1126 1143	Tara Re- reel	200	Cable laid without incident. Tara 30.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
99A 99B	99	10/13 1210 1228	Tara Re-reel	50	Cable laid without incident. Tara 31.
100A 100B	100	10/13 1255 1311	Tara Re-reel	100	Cable laid without incident. Tara 32.
101A 101B	101	10/13 1353 1412	Tara Re-reel	100	Cable laid without incident. Tara 33.
102A 102B	102	10/13 1438 1455	Tara 3705# 1500'	100	Cable laid without incident. Tara 34.
103A 103B	103	10/13 1513 1532	Tara Re-reel	100	Cable laid without incident. Tara 35.
104A 104B	104	10/13 1554 1613	Tara Re-reel	150	Cable laid without incident. Tara 36.
105A 105B	105	10/14 0725 0748	53966 3800# 1600'	∞	Cable laid without incident.
106A 106B	106	10/14 0818 0838	Tara Re-reel	100	Cable laid without incident. Tara 37.
107A 107B	107	10/14 0856 0912	52087 3825# 1600'	200	Cable laid without incident.
108A 108B	108	10/14 0932 0952	Tara 3755# 1500'	100	Cable laid without incident. Tara 38.
109A 109B	109	10/14 1036 1054	Tara 3750# 1500'	150	Cable laid without incident. Tara 39.
110A 110B	110	10/14 1112 1132	Tara 3700# 1500'	150	Cable laid without incident. Tara 40.
111A 111B	111	10/14 1146 1201	Tara Re-reel	150	Cable laid without incident. Tara 41.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	COMMENTS
112A 112B	112	10/14 1215 1235	Tara Re- reel	200	Cable laid without incident. Tara 42.
113A 113B	113	10/14 1309 1329	Tara Re- reel	100	Cable laid without incident. Tara 43.
114A 114B	114	10/14 1338 1358	Tara ---- 1500'	200	Cable laid without incident. Tara 44.
115A 115B	115	10/14 1410 1430	Tara No Marks	125	Cable laid without incident. Tara 45.
116A 116B	116	10/14 1443 1501	Tara ---- 1500'	50	Low megger reading (40 MΩ) initially. Laid without incident. Tara·46.
117A 117B	117	10/15 1050 1107	92305 3400# 1305'	∞	Unused end of #42 (165 feet) spliced onto short reel. Cable laid without incident.
118A 118B	118	10/15 1026 1225	Pirelli ---- 1365'	∞	Unused end of #57 (120 feet) spliced onto short reel. Cable laid without incident.
37A 37B	119	10/15 1240 1300	93250 3890# 1600'	∞	Re-lay of cable #37. Previous unacceptable megger reading caused by wet reel/ground at end. Cable laid without incident.
1A 1B	120	10/15 1313 1345	54184 3955# 1600'	GR	Re-lay of cable #1, cut to length of loop 9/18/82. Additional cable spliced to #1 aboard camel at south quay; secured there while LCM circled loop. No megger tests during lay. After curing slack pulled back through "A" end. Megger went from 200 MΩ to zero when splice entered water, indicating failure?
~~1A~~ ~~1B~~	~~120~~	10/19			Cable retrieved due to failure.

END DES	LAY NO.	LAY DATE TIME	CABLE REEL LABEL	RES MΩ	LOG OF CABLES RETRIEVED
	1				Pirelli 54184
	2				Pirelli 92339
	3				Pirelli 92328
	4				Pirelli 54037
	5				Pirelli 53359
	15				Pirelli 92834
	21				Pirelli 54009
	30				Pirelli 53600
	36				Pirelli 54071
	43				Pirelli 56411
	86				Tara 19
	88				Tara 21
	96				Tara 29

APPENDIX B

Z-LOOP CABLE INSULATION RESISTANCE MEGGER READINGS AFTER 1982 INSTALLATION

BOX 1 CIRCUIT 1 (RIGHT)	
Cable** Identification	Resistance In Megohms
6	300
7	200
8	200
9	200
10	100
11	100
12	100
13	6
14	75
16	100
17	100
18	100
19	100
20	100
22	100
23	40
24	100
25	100

** Designation as given in Appendix A

BOX 1 CIRCUIT 2 (LEFT)	
Cable Identification	Resistance In Megohms
26	100
27	50
28	100
29	100
31	100
32	100
33	100
34	100
35	100
38	100
39	100
40	100
41	100
47*	100
44	100
45	100
46	100

* 47 Replaces #42 which is grounded and abandoned

BOX 2 CIRCUIT 3 (RIGHT)

Cable Identification	Resistance In Megohms
48	100
49	100
50	100
51	100
52	5
53	100
54	100
55	100
56	100
57	100
58	100
59	100
60	100
61	100
62	100
63	100
64	100

BOX 2 CIRCUIT 4 (LEFT)

Cable Identification	Resistance In Megohms
65	100
66	100
67	50
68	50
69	50
70	40
71	100
72	100
73	100
74	50
75	50
76	50
77	100
78	50
79	50
80	50
81	50

BOX 3 CIRCUIT 5 (RIGHT)

Cable Identification	Resistance In Megohms
82	50
83	5
84	50
85	100
87	50
89	50
90	50
91	100
92	50
93	50
94	50
95	50
97	100
98	50
99	30
100	50
101	50

BOX 3 CIRCUIT 6 (LEFT)

Cable Identification	Resistance In Megohms
102	50
103	50
104	50
105	100
106	50
107	100
108	50
109	50
110	50
111	50
112	50
113	50
114	50
115	50
116	30
117	100
118	10
37	100

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